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MANAGEMENT AND OPERATION OF A CANADIAN WATER WORKS SYSTEM[1]

BY W. E. MACDONALD[2]

The management and operation of a system of water works are often believed to require essentially a business management. Regarded in a broad and comprehensive sense this view may be correct, for a far seeing business management would not overlook the purely technical or scientific considerations which are necessarily involved in the management of a modern water works system. The questions involved do not relate solely to the sale of a commodity supplied in the form of a water service, but also deal with the quality of the water supplied and the design, construction, and operation of the physical property by and through which the service is rendered.

Engineering in its basic principles is another term applied to the economics of design and construction, and is the fundamental basis of good management in the operation of an efficient modern water works plant.

The first consideration or duty of a water department is to give to the community an adequate supply of water, hygienically safe for drinking and satisfactory for industrial purposes at the lowest equitable rate. Such a supply will reduce sickness and death, as well as avoid economic losses of no small magnitude.

[1] Presented before the Toronto Convention, June 26, 1929.
[2] Water Works Engineer, Ottawa, Canada.

The first essential element in an efficient water works department is the organization of a staff of competent employees. The engineer in charge or executive should possess special qualifications and experience in his particular line of work. The manager forms the connecting link between the public and the employees and it is, therefore, essential that he be a man of understanding, of decision, tact and enthusiasm. The chief executive should be free to organize and select the personnel of the staff and have the necessary power to establish the salaries to be paid, giving due consideration to the qualifications of the applicant for the position to be filled. Through such authority only is it possible to operate successfully the department and to promote efficiency. In the course of operation of the department when vacancies occur, these positions should be filled as far as possible from the ranks of the existing personnel, thereby affording the applicant an opportunity to qualify for promotion, as a result of transfers, dismissals or resignations. The employees soon realize the benefits to be gained from such a system and this creates a keener interest in their work, resulting in greater co-operation and ultimately successful operation of the department.

The problem of water works management is to secure a vision of the possibilities and organize the department with a view to placing it in the first rank of leadership in the city which it serves. The need for uniformity of supply, accurate records for the distribution system, an adequate distribution system and a proper accounting system are all more or less important parts of the major structure centering about one individual. The efficient manager will solve these various needs by selecting competent heads for the different divisions and then lean heavily on them. In this way the chief is relieved of a multitude of detail and left free to think and plan along broad constructive lines.

COST ACCOUNTING

There is no problem in municipal operations more important than the adoption of a thorough system of accounts through which a full and comprehensive report of the municipality's financial condition may be determined at any time. The cost accounting system should be of such character that it renders easy comparison of unit costs and makes it possible to exercise greater efficiency and economy in extending and operating the system.

VALUE OF UNIFORM RECORDS

By means of uniform cost accounting records one is enabled to tabulate the various costs of maintenance and construction works, from which an analysis at any time will disclose the foremen who are producing the best results and thereby allow the elimination of the less desirable. This information will permit of more accurate estimating by the engineering staff and will result in lower costs, in itself more than compensating for the cost of maintaining a unit cost system.

WATER RATES

During the past few years there has been a general increase in the cost of labor and material and the administrative head can only arrive at an equitable rate for water, from year to year, from an analysis of his true costs covering pumping, purification, distribution and fixed charges as revealed from his cost accounting system. It has been found, from a recent study of the rate situation in both American and Canadian cities, that, by efficient management in effecting certain economies, the water rates have not been increased in proportion to the increased cost of labor and materials.

In all municipalities water should be furnished at the lowest reasonable cost, which will permit the system to be well operated, to maintain it in efficient condition, to pay off annually at least a part of the outstanding indebtedness and to provide for the interest and sinking fund.

PLANNING A WATER WORKS

The planning of a water works, both in its original form and in improvements for greater efficiency and more production, is a matter that must take into consideration not only immediate needs, but also requirements of the future, when growth and extension of the municipality will call for greater facilities. If these increases or future demands are not foreseen and provided for, then at some future time when such improvements are imperative, their cost will be a hundredfold greater.

OPERATION

The operation of a water department demands continuous service. There is no period of shut down and employees must always be on duty in order to safeguard and protect the lives of the citizens, as

well as to maintain an efficient and continuous service. To render this service all branches of the water works service must be maintained at all times at the highest degree of efficiency.

In this paper, it is my intention to present for discussion a general outline of how a Canadian water works system is operated, with a view to obtaining the utmost efficiency of service.

BUREAU OF PURCHASES AND SUPPLIES

By instituting a bureau of purchases and supplies it has been found possible to effect substantial savings in the purchase of material and supplies. Requisitions for goods from time to time are made to the purchasing officer in charge of this division and by planning the work, where possible, well in advance, purchases can be made in quantities. When advantage is taken of low prices prevailing during certain periods when the manufacturers are over-stocked substantial savings may be effected, provided adequate and well located storage space has been arranged for.

PUMPING STATIONS

In recent years, many factors have largely been responsible in changing the trend of pumping practice. Probably one of the most important changes wrought has been the introduction of the centrifugal pump, which has become a serious competitor of the reciprocating steam engine driven type. The extended use of electricity has caused the installation of electrically driven centrifugal pumps as a moderate and convenient means of handling large and small quantities of water under almost every conceivable condition.

In Canada the difficulties of operation in winter through the formation of frazil ice have been greatly lessened by the use of revolving screens combined with the application of steam.

PURIFICATION PLANTS

Time will not permit in this paper to discuss at any length this most important phase of the water works plant.

The City of Ottawa has recently carried a Money By-Law covering the construction of one new 34 m. g. d. rapid sand purification plant.

However, before proceeding with the actual construction of this new plant we have first erected a preliminary or experimental filter plant having a rated capacity of 100,000 imperial gallons per day.

The purpose of this preliminary plant is two fold: (a) to reduce the capital cost of the final plant and (b) to reduce to a minimum the annual cost of operation.

This plant has been in operation since February last and during this short period of time much valuable information has been obtained which will now result in radical changes in the design of the larger plant to meet most efficiently our local conditions.

DISTRIBUTION SYSTEM

The distribution system should be so designed that it will be capable of supplying adequate quantities of water throughout the entire district for domestic and commercial purposes as well as for fire extinguishment. The cost of a distribution system is usually the largest expenditure of any water works and consequently great care must be taken in both the original design and in the extensions.

The planning of a water works distribution system with respect to improvements looking to greater efficiency and more production, is a matter that must take into consideration not only immediate results, but also requirements of the future, when growth and extension of the municipality will call for greater facilities.

New main extensions—method of procedure

In discussing this subject, for the information of my southern friends, it may be of interest to you to know that in many cities throughout Canada the frost penetrates into the ground for a depth of from 4 to 10 feet below the surface, necessitating installing mains in many cities west of Winnipeg, with a minimum covering of 11 feet, to prevent mains from freezing. It is therefore important that the engineer should have definite knowledge in advance of the frost penetration in various grades of soil in his own municipality to permit the mains to be installed with a minimum of covering to safeguard freezing, yet avoiding an installation at too great a depth incurring an unnecessary cost.

In regard to the construction work carried out by the City of Ottawa in connection with new water main extensions, where a minimum average covering of 7 feet is necessary, allow me to set forth the procedure established. When it is proposed to make extensions the engineer in charge has a report prepared with estimates and detailed plans showing the cost of construction, the required revenue and the estimated revenue from the property served by the

extension. The work having been duly authorized, the engineer then selects the most competent foreman, and issues an official work order, to which is attached a blue print showing the new extension, giving the location of all valves, hydrants and specials. These work orders, in triplicate, contain detailed instructions to the foreman and state definitely the amount of material he is permitted to requisition from the corporation stores. The effect of these orders is to allow the foreman to receive from stores, only the exact amount of material as contained in the engineer's estimate, thereby tending to economy. Upon completion of the work, all material and labour are entered on the order and all changes and installations are indicated in red on the blue print and returned promptly by the foreman to the draughting office where a permanent record is made.

Unit costs

The department requires the foreman to make, each day, a complete report of the day's operations which includes the following items: The cost of the work performed each day, complete cost to date, materials used each day, and a complete summary of work carried out to date. From these reports the department completes its records in detail, which are submitted to the engineer, and from which he is at once able to make an analysis of the unit costs of all foremen. The effect of these records greatly increases the efficiency of the foremen, who soon realize that a permanent record is maintained of their work.

Care in main laying

In the past there seems to have been a tendency to use less care in the construction of the distribution system than was exercised in the construction of any other part of the water works system. This may have been due to the fact that the work was soon covered and out of sight, or from previous lack of experience in good construction practice. Whatever the reason, it has resulted in the development of much trouble, often occurring at the most inopportune times and resulting sometimes in heavy property damage and loss of life. Having a previous knowledge of all this, the City of Ottawa is most careful in the installation of all mains and services. All cast iron pipe, gate valves, meters and special pipe castings are subject to a standard hydrostatic test before acceptance and must be certified as having satisfactorily met these requirements by one of the official

inspection companies. In addition to this as a secondary precaution against the possibility of trouble developing later, the resident engineer is required to see that all pipes and fittings are properly in alignment in the trench, and that sufficient supports and necessary tie rods are in place. When this condition is satisfactory, the pipe must be filled with water and the pressure raised to permit an examination for any defects previous to backfilling of trench.

Protection from frost

In many Canadian municipalities, owing to extreme cold weather conditions, in service and main laying it is not always possible to secure sufficient depth of covering to prevent freezing. For example, in the following types of construction, where pipes are suspended across rivers, supported on viaducts, intersect subways and tunnels, it is absolutely necessary, in order to secure protection from frost, to have all such pipes and fittings properly insulated.

Insulation

During the past fifteen years the City of Ottawa, like many other Canadian municipalities, has experienced considerable trouble through interruptions to its service with the resultant damage and monetary loss through the freezing and bursting of many large water pipes and valves. This trouble has invariably occurred during the coldest winter weather, sometimes when the temperature has been as low as 30 degrees F. below zero. To prevent the reccurrence of this experience the engineering department of our city now insists that all water pipes, valves and fittings exposed to freezing temperature must be sufficiently insulated against cold to prevent damage by freezing.

Various forms of insulating experiments have been carried out by the department during the past few years but probably the best protection has been secured from the following method:

Method of insulation. The pipe itself is wrapped with one layer of hair felt one inch in thickness and secured to the pipe with a wrapping of heavy jute twine at 2-inch centers. Over this is applied one layer of heavy asphalt saturated felt secured in place by the wrapping of jute twine. This process is repeated in its respective order until four complete wrappings have been made. On top of the fourth layer of hair felt is placed a close winding of special electric insulating tape to hermetically seal the joints, and when this is

finished it is given a treatment of asphalt compound. The insulated pipe is then wrapped first with oiled paper and an additional lining of heavy rosin sized paper. To protect this insulating material against weather conditions the whole is finally enclosed in a jacket of 8 oz. canvas which is treated with a heavy coat of glue sizing and then with two coats of first quality white lead and linseed oil paint.

Maintenance of system

There are few works which require greater care and more constant vigilance on the part of its employees than does the operation and maintenance of a public water supply. Under the operation and maintenance division there must be considered the following appurtenances, inspection and maintenance of fire hydrants, valves and meters, prevention of electrolysis, regular and systematic survey for the detection of leaks, thawing of frozen services and finally the efficient handling of all general and emergent repairs to the system throughout the twenty-four hours each day.

FIRE HYDRANTS

The proper functioning of fire hydrants in all municipalities is a factor which should receive utmost consideration from the authorities. It is not good business to pay annually huge sums of money to maintain an efficient fire brigade, unless the water works department is maintained on an equally high standard of efficiency.

In Canada, particularly, it is necessary to see that fire hydrants are correctly installed to insure proper functioning in service at all times. In the installation of fire hydrants it is highly desirable to see that all lateral connections are equipped with special control valves and laid at a sufficient depth below the frost line to prevent freezing. The hydrants themselves should be plumbed, well set and provision made for drainage to the adjacent sewer. If the foregoing practice is rigidly followed it will be found that the trouble through freezing will be greatly minimized.

However, in many of the most northern Canadian cities, especially with regard to previous installations, it is necessary during the freezing period that all fire hydrants be inspected at regular intervals. In Ottawa we find it necessary to examine all hydrants in the business area every 24 hours, while the hydrants in the residential sections are inspected every 48 hours. Perhaps one of the most efficient methods

of ensuring that this hydrant inspection is properly carried out is to insist on the inspectors marking, in chalk, on the hydrant, the date of inspection and the letter "A" or "P," indicating morning or afternoon. When making the next inspection these chalk marks are effaced by the inspector and the new time and date again indicated in chalk.

GATE VALVES

One of the most important items and one which often receives slight attention, is the proper location and maintenance of gate valves. In the City of Ottawa, at every opportunity and especially previous to laying of new pavements the department installs sufficient additional valves to decrease the sectional shut down, so that at any time it will not be necessary to close down more than one city block. All gate valves are installed in chambers and are inspected at least annually, for the detection of gland leakage and to ascertain if they are in proper working order. At such times the stuffing boxes are packed, gearing lubricated and a test made to determine that the valve is fully open.

METERS

The sale of water through meters has become now nearly a general practice, resulting naturally in a rapid increase in the number of meters in service, and requiring increased attention for their proper care and supervision.

In Canada, to date the full benefit of the metered system is not fully apparent, as few of the municipalities are one hundred per cent metered. However, practically all of the Canadian cities have realized that the selling of water by measurement is the only equitable way and they are rapidly endeavouring to organize this important branch of the service on a proper basis with a view to increasing the number of metered services.

To carry out successfully a meter program in the city, we have built up an organization as a separate branch of the service whose duty it is to test, install, read, repair and systematically record the individual performances of all meters. The records established by this branch of the service have been of inestimable value in selecting and purchasing the highest quality of meter and, in addition, in allowing the superintendent to maintain an accurate check on all services so that the water works department is assured of all income justly due.

ELECTROLYSIS

The City of Ottawa has not been greatly troubled by electrolysis, owing to the fact that all returns from the street railway power lines have been grounded to the cast iron distributing header. This procedure has greatly minimized the trouble from this source.

DETECTION AND PREVENTION OF WATER WASTE

The problem of reducing the waste of water which invariably occurs in all unmetered cities and towns should receive an amount of attention, from engineers and water works officials, equal to that formerly given to the problem of securing additional supplies, when the demands for water bid fair to exceed the capacity of the source in service.

The three methods most effective in reducing wastes in the City of Ottawa have been as follows: (a) Regular inspection, (b) waste water surveys, and (c) installation of meters.

Inspection

A large percentage of the careless waste in buildings from defective plumbing and fixtures can be controlled by a systematic interior building inspection by competent and specially trained inspectors in uniform. The work of these inspectors is rigidly backed up by the department and all consumers must maintain the plumbing in a satisfactory condition, otherwise, failure to do so will result in the supply being temporarily discontinued.

In many Canadian cities, contrary to the prevailing practice in the United States, it is common to have the peak consumption occur during the coldest winter months rather than in the warmest months of the summer season. This unusual condition is brought about by the consumers allowing the water to run to waste to prevent freezing. This condition of waste is not one which should be tolerated or accepted in any city as a solution of the cold weather problem of freezing. An effective method of overcoming this extravagant waste has resulted from the work of our uniformed waste water inspectors covering the entire city during the cold weather period and reporting to the engineering office all consumers found running water to waste to prevent freezing. On the receipt of the information, the owners are informed by letter that this unnecessary waste of water must cease and that the pipes and fittings must be protected and insulated

against cold. These notices usually allow the owner a period of time not exceeding six months to comply with this regulation. This work is well worth while, as demonstrated by the fact that during the past three years we have reduced our daily average winter consumption by more than two million gallons.

Waste water surveys

The determination of underground leaks and their ultimate repair is a work which occupies considerable time and in the larger cities is best handled by the organization of a separate pitometer branch of men specially trained in this work. The results of these surveys are wholly dependent upon the initiative and the efficiency of the operator in charge.

Meters

Of all means for the reduction of waste there is none more beneficial for securing results than the introduction of high quality meters. All water departments are well advised in working towards a hundred per cent metered supply.

THAWING OF FROZEN SERVICES

Until a few years ago probably one of the most vexing questions confronting the officials of a Canadian water department, during the winter months, was the freezing of service pipes. The City of Ottawa, during the extreme weather conditions, probably was affected with more frozen services than any other city on the Continent. There have been winters in Ottawa when services of more than three thousand consumers have been frozen and the department in years past was unable to cope with this situation with the result that many hundreds of families in previous years were without water for many weeks at a time. Like all other water works problems requiring action the City of Ottawa took hold of this situation in 1919 and discontinued thawing services by the former unsatisfactory transformer method and designed and constructed four self-contained electric thawing apparatuses. The success of these new machines has been truly marvelous in rendering a prompt and efficient public service as well as in having reduced the cost of each thawing operation from \$6.05 to \$1.78 per service, effecting an individual saving of \$4.27 per service. Allowing for all operating costs, interest and depreciation, the thawing machines have been directly responsible in saving, during the past few years, \$23,000.00.

The city has carried on a program of lowering and insulating services where necessary. With many of these, where continual trouble from freezing was experienced in the past, this work, together with the new machines, has done much to lighten the burden of the water department during the winter months.

KEEPING THE FINGER ON THE PULSE OF THE SYSTEM

To insure definitely that the service of the department is being efficiently maintained at all times during the twenty-four hour period we have inaugurated in Ottawa, a central headquarters bureau. The purpose of this office is to coördinate the various branches of the water department. At this office all complaints are received and the officer in charge is continuously informed of the working of the entire department, receiving hourly readings of gauges from the pumping stations, transformer stations, and filtration plant, as well as pressure gauge readings from all city fire stations. This office is equipped with a fire alarm gong, and an automatic pressure gauge. It has a complete set of plans of the entire distribution system, giving exact location of all mains and valves.

EMERGENCY SERVICE

Emergency service is a most important part of the water department's responsibility in safe-guarding the lives and property of the citizens. The City of Ottawa has placed this service directly under the central headquarters office. To meet this situation we have specially trained employees operating two emergency trucks completely fitted with all supplies and appurtenances. As a means of assistance in controlling breaks within a minimum of time we have had erected at every intersection in the city valve location plates, giving definite information as to the size and location of each valve. These plates have been of great value, especially in the winter season when it is quite usual to have several feet of snow over many of the valve covers.

CONFIDENCE THROUGH PUBLICITY

Municipal officials can make the work of their departments far more effective by taking the public into their confidence. This can best be accomplished by a judicious use of publicity through the daily press in both its editorial and advertising columns; by assuring the public of the safety of the supply; by the encouragement of the

citizens to visit the water works plant; and by seeing that the visitors are made welcome, and shown over the plant and are intelligently advised as to its workings. At all times see that the public is well informed on the services you are performing, for even though you may consider your local organization ideal, the citizens will not consider it so unless you have the press support back of it.

DISCUSSION

J. Walter Ackerman:[3] Mr. MacDonald's paper on management and operation gives in general a clear and trite demonstration of what a properly constructed and operated waterworks should be, and represents to my mind the conclusions, of not only a carefully trained but an experienced man of mature judgment.

One of the few things I missed in his opening remarks that seemed to me important was, the establishment of cordial public relations with the users. This has not been stressed and I think it is an important point to try to create a feeling of good will between the water rate payer and the waterworks management.

One other suggestion I have to offer is, the relations with the other city departments. Too often I find that there is a feeling of superiority or jealousy between the general department of public works and the water department, provided they are not operated from one head. In many of our cities at the present time the waterworks is but a bureau under the department of public works. In that event this feeling is not so apt to exist, but in those places where the waterworks is operated through a separate commission this feeling persists. In my own city such work as the replacing of pavement and the filling of trenches under the pavement is done by the public works department at specified prices. There can then be no division of responsibility as to trouble from sunken trenches or poor pavements.

As Watertown is in the northern latitude of our country, it is supposed to be somewhat colder than other places. However, you would have hard work trying to prove it to a resident of that city, because they will tell you that 18 below zero is just nice wholesome winter weather and serves to give one a broad outlook on life and raises his vitality, etc. This same temperature, however, is not conducive to the easy operation of waterworks plants with their attendant difficulties and troubles.

[3] City Manager, Watertown, N. Y.

As to the question of construction cost in cold climates, it is bound to enter into the laying of mains because we do not lay any main less than with a 5 to 5½ foot cover. As our terrain is mostly of rock formation, you can readily understand the last foot or two of excavation is expensive. As to those places where the water main is exposed in river crossings or on bridges, it is necessary, of course, to insulate them. In our own case the installation is as follows:

First, the water main is covered with one coat of tar paper wired securely around the main with copper wire and given a coat of tar paint. The second coat consists of two layers of hair felt. Each one of these layers is about 1½ inches thick. This is also held in place by a wire or heavy cord. Then a canvass cloth is either sewed or wired around the hair felt and this is given two coats also of tar paint. The final covering consists of two layers of heavy tar paper wired in place which is painted with two coats to protect the entire covering to make it water resisting. On one bridge this covering is surrounded by a wooden box for further protection.

One of the other troubles in a cold country is the question of maintaining fire hydrants in proper operating condition. For instance, when freezing weather occurs, an inspection crew is organized whose business it is to make daily inspections of all hydrants suspected of having any water in them. From year to year our records show where this usually is to be found.

While Mr. MacDonald says it is their practice to drain to the sewers, in our city and in many others, I imagine this is not always available and consequently we must resort to other methods. Whenever we can keep a hydrant dry we attempt to do so, but in case this is impossible we place denatured alcohol in those hydrants in which water is bound to rise and then this solution is tested from time to time. Every hydrant that has ever given us any trouble is inspected daily to determine if there is any ice therein. If ice is found, it is thawed by hot water which is taken on the job with the service truck and an anti-freeze solution placed therein.

The next cold weather difficulty is in the freezing of service pipes. This is cared for by a small machine which has been designed and built locally and is on the market for that purpose. The first one was designed and built for our own plant. This consists of a Ford engine with a generator made to develop the proper current, and we find that from 2 to 10 minutes is the extreme limit for thawing service pipes.

In connection with this there has developed some difficulty where leadite or other similar jointing material is used, because that presents an insulating joint that makes difficult the passage of heavy enough current to thaw a service pipe. However, this objection is advantageous in another way, as it is a protection in some cases against electrolysis, although in our own case we are not troubled thereby, since the street cars are gradually being displaced by busses. In a few years time the trouble with electrolysis will be ancient history, due to the fact that it appears that the street car with its direct current is doomed.

I approve by all means of uniform records, and this will always be of interest to the manager of a plant to show him from year to year whether or not he is holding his costs down to compare favorably with prior periods.

There is no more trite saying than a waterworks demands a continuous operation. There are no Sundays or legal holidays that admit of turning off the works for the afternoon for a picnic. Someone has got to be on the job for every day of the year and every minute of the day and this, in works of any size at all, must be maintained in order to meet the present day exacting demands.

While purification is only briefly mentioned, it has become almost an integral part of every works. It is seldom that any waterworks today can be safe without some purification process, and there is no other one thing that has reduced the mortality of typhoid fever as much as filtration and other purification process.

As to metering, no works can render anywhere near justice to its consumers unless the entire system is metered. When this is done the question of wasteful use has been automatically cared for and it would not then require any of the methods of house inspection and checking of flat rate users as to fixtures used, etc. While perhaps the immediate introduction of a completely metered system after a long use of flat rates will result in many complaints, it will be but a very short time in which this will be entirely obliterated so far as the question of metering or flat rate is concerned. You will always have the person who thinks he is being charged too much if his bill is 10 cents more for one quarter than it was in any other.

R. L. DOBBIN:[4] In meeting in the waterworks associations we are prone to stress the technical end of our business, and the practical

[4] Superintendent, Waterworks, Peterborough, Ont., Canada.

application. Very little is said about our public relations, which after all, are probably one of the most important aspects with which we have to deal. Pure water, and lots of it, is of prime importance. The ordinary water consumer, however, judges the efficiency of the plant by the treatment he gets at the office. The first contact that most water consumers have with the management is when they call on the telephone to complain about something. We should be very careful that the person who answers the phone in the first instance is properly trained and courteous. That person should be able to give the information, or to say where the information can be obtained, and he should see that the information is obtained. Another point where the waterworks department can help produce a good feeling towards the department, is in the beautifying of the grounds around the pumping station and the filter plant. When the water consumer goes into a plant that is properly taken care of and in good shape, and the grounds look nice, he comes to the conclusion that the water must be all right.

There are various financial matters that affect the value of waterworks systems. In taking care of capital expenditures, and in the extension of mains, you must consider the amount of revenue you have in sight before you can start the work. These troubles should be discussed more than they have been in the past.

The establishment of a pension system has recently been taken up in the Province of Ontario. It might be of interest to you to know that an arrangement has been made with three insurance companies to establish a pension system for all of the public utilities governed by commissions in the province of Ontario, that is, electricity, water, and gas. All the officials and permanent employees of these utilities are going into one grand pension scheme, under the supervision of the Hydro Electric Commission of Ontario. It is based on somewhat similar plans adopted by the government. The employee will pay 2½ per cent of his salary, and the Commission or the Water company will pay 5 per cent. The employee receives on retiring a pension ranging from 75 per cent of his last year's salary, down to probably 50 per cent, with a minimum pension of $800 a year.

Mr. Ackermann referred to the troubles with electrolysis. In Peterboro we have solved that problem by getting rid of the street railway and operating buses. You gentlemen who come from south of the line consider that Canada is always cold, but I presume your minds have been disabused of that thought during the present week.

We do have considerable trouble with cold weather in Canada, and perhaps for five months of the year the danger of frost is before us, and our distribution systems are designed with that end in view. Our services have to be placed at an abnormal depth to keep them from freezing. We have to be very careful as to how they are laid, and in what kind of soil they are laid. We must see that there is no object that will conduct the cold down to the pipes. Speaking of thawing the services by electricity, I find that in most towns they are using copper piping. With the increasing tendency to use copper piping I have been wondering what effect that is going to have on electric thawing. Thawing of the service pipe by electricity, of course, depends upon the resistance created in the pipe by the current passing through, and as copper is said to be a conductor of electricity, there will not be as much heat generated as there would be in iron or lead pipe. I have been wondering whether electric thawing will be effective on copper pipe.

We have been having trouble with trying to thaw very short services by electricity, because we just establish a short on the line, and the current created is not very strong. We have had no experience in thawing copper services as yet.

The inspection of fire hydrants during the winter is very important. They should be inspected as often as practicable. It is probably not practical to inspect them every day. Hydrants in the business district should be inspected every day and in the residence district once a week, depending on the location of the hydrant and its history.

Geo. G. Routledge:[5] I am very much interested in that part of Mr. MacDonald's excellent paper, in which he refers to the freezing and bursting of water mains. I should like to make a few remarks in this connection, although they will only be indirectly applicable to management and operation.

I am always very uneasy when frost penetrates the ground to a considerable depth, because, at such times, I feel there is a great force in operation, which in its effect on water mains under such varying surface and subsurface conditions, is difficult to understand. In Toronto, after enjoying a few years' freedom from breaks on large mains, we had two on 36-inch lines, last winter. In both cases, the mains were well below the frost line and there was nothing to

[5] Superintendent, Water Distribution Section, Toronto, Ont., Canada.

indicate water hammer. In an effort to discover the cause of the breaks, a thought struck me, which I want to pass on to you for criticism.

When a section of ground on the line of a water main commences to heave with frost, a leak at that point will almost invariably be found, or, the ground is saturated with water from some other source. I am inclined to think the two breaks referred to were due to the soil at those points being saturated with water. With the surrounding soil comparatively dry, unequal expansion when frozen resulted.

Where there is a heavy concrete roadbed, the resistance to the heaving effect of a water saturated spot, when frost sets in, is considerable. When the frost has penetrated to a depth of 3 or 4 feet, there is a frozen slab of tremendous strength, particularly if the concrete is reinforced with street car tracks.

Increased expansion at a wet spot will act as a pillar to the slab, and, if it is directly over a water main, it is conceivable that a load more than sufficient to break the main may result.

I would like to ask Mr. MacDonald if he considers that some breaks might be caused by conditions such as I have attempted to describe.

Mr. MacDonald:[2] I cannot say that we have anything of that nature, Mr. Routledge.

Question: Do you place the meters in Ottawa outside the house line, and if so, how do you place them?

Mr. MacDonald:[2] The general practice is to place all water services inside the building, but in some cases that is not possible, owing to apartment houses containing living quarters in the basement. In that event they are placed in the boulevard inside the sidewalk.

Question: Do you use alcohol to keep the hydrant from freezing?

Mr. MacDonald:[2] Mr. Ackermann made mention of using alcohol, and diluting it with water, to keep hydrants from freezing. We find that is not satisfactory, because in many cases we get the freezing just beyond the gate valve in the hydrant. We have had a great deal of trouble from that source.

QUESTION: How do you discover leaks?

MR. MACDONALD:[2] We cannot do a great deal of work in discovering leaks at Ottawa during the winter time. We do that work in the spring and in the summer. We start at the outskirts of the city in the early spring, and the crews are put to work during the midnight hours. We have a previous record of the total flow of each district, and we know the exact population in each area. We then establish whether there is an increase or decrease of water consumption. If we find an abnormal increase, we subdivide the area, and bring it down block by block, so that we know exactly the consumption in each area. We start out with a master meter, and close all the valves. We find it much more advantageous to take a manual reading than a 24 hour reading. Once we get down and find that there is just one block in the whole area that is excessive, we go over the individual services in that particular area. We shut them off at the curb cock, one at a time, and at the same time do the reading. If we find a large drop in the flow of a certain service, and that the service has been cut down, we generally find that the excessive consumption is on one or more particular services inside that block. If the excessive consumption is not detected in that way, the following morning a trained man is sent to that particular block with detecting devices and a pressure gauge. He reads all individual services, and in that way we confine it to 15 or 20 feet. This can only be done within the midnight hours, because any noise within a mile would be detected on this instrument.

QUESTION: How often do you do that work?

MR. MACDONALD:[2] We carry that work on during the entire six months, and we cover the whole city once a year.

QUESTION: How do you keep the meters so that they will not freeze?

MR. MACDONALD:[2] Our dials are on the meter itself, and we have little or no trouble from moisture. If we have any trouble the meter glass is removed. The chamber is sufficiently large to permit the reader to get down into the chamber to take the reading.

QUESTION: How does the reader get down into a seven foot pit, and out again?

MR. MACDONALD:[2] It is four feet square, and there is a cover 24 inches square on the top to permit easy access.

QUESTION: Who pays for that meter pit?

MR. MACDONALD:[2] The city bears the expense of the installation of the meter, and there are no meter rentals. Up to three years ago we had meter rentals. We now have a flat rate on the assessed value of the building and the land. That rate prevails until such time as the meter shows an excessive use of water, or an excessive cost of the water at our usual rate of 12 cents per thousand gallons.

QUESTION: What method do you take to find out whether a hydrant is freezing?

MR. MACDONALD:[2] The business section of the city is covered every 24 hours, and the residential section every 48 hours.

The very worst thing the operator can do is to fill the hydrant with water. We occasionally have trouble breaking in new men. The examination is first made by the use of a plumb bob to see that the hydrant is perfectly dry, and even then we may find it absolutely dry and still not be sure that water is available unless the valve has a free movement. Our valves are designed so that we can give them one and a half turns before they allow any water to enter the hydrant. If the valve is free we then know that the hydrant is not frozen. We have found an efficient way of thawing hydrant branches by conveying 5 to 10 gallons of water on a service truck from our down town department to the hydrant and pouring that boiling water into the hydrant and leaving it there for a space of from 15 to 20 minutes. We then pump it out. That will draw the frost for some distance from around the hydrant barrel and maintain the hydrant in operation during frosty weather. The hydrant may be entirely empty of water and yet be frozen between the hydrant and the vent. If the hot water will not release the frost we pour the valve box full of hot water, usually from 5 to 10 gallons. We leave it there for an hour or two and then pump it out. We have maintained a hydrant branch where it was entirely surrounded by frost several

weeks by giving it two or three doses of hot water weekly. We find that removes the frost from the hydrant better than anything else.

A MEMBER: Referring to hydrant inspection we find it is not necessary to use a plumb bob. If the inspector has a lot of experience, all he has to do is to remove the cap and slap the hose nozzle with his hand and he will get a certain sound, if there is no water. He can tell immediately whether the hydrant is frozen or not. We have a man for that work who has had some experience.

We find that daily inspection is the only efficient method of maintaining fire hydrants. It costs us about $1200.00 a year for daily inspection and our residential district is inspected every 48 hours. We feel that it is much cheaper to spend the money in that way than lose it by having to pay for repairing hydrants, or by losing taxes on account of a large fire destroying a factory or merchant's premises.

Referring to Mr. Routledge's question regarding the breaking of mains from frost pressure, I am inclined to agree with him that frost penetration is the cause of the breaking of water mains in a section where the country is subject to heavy frost. I am forced to that conclusion because we have had it happen in Sudbury where we have had our most serious breaks during our hard winter, when the frost will penetrate 5 or 6 feet. It creates a tremendous pressure on the main.

Regarding the thawing of copper service pipes we have had experience along that line. We have thawed copper pipes with the ordinary transformer method, and with a low voltage. We use $37\frac{1}{2}$ and 75 volts with our transformer. If the resistance is high we use 75 volts, and if the resistance is low we use a low voltage, and we find that copper service pipes present no difficulty whatever.

ANDREW F. MACALLUM:[6] Mr. MacDonald did not tell you that the electric apparatus we use for thawing out pipes was designed by him. We have tried steam boilers and other electrical apparatus and found them not satisfactory, but the apparatus that Mr. MacDonald designed and is now used in Ottawa and several other cities. works out very effectively. I doubt if that method of tapping on the

[6] Commissioner of Works and City Engineer, Ottawa, Canada.

side of a hydrant to see whether it was frozen or not would be effective in our district. So much would depend on whether the operator had an acute ear for music. Dropping down the plumb bob seems to be the quickest way to find out whether there is trouble or not. In one district in Ottawa we have rock formation, and it is a pretty poor district with nearly all frame houses. As a rule these people let their water run in the winter time. It is a waste of water, but if they did not do that the pipes, entering a frame building where the foundation is light and the pipe is exposed, are bound to freeze. For that reason they are allowed to keep the water running. Some might shut off the water. In exercising a proper water works judgment, you must use a certain amount of the milk of human kindness.

James E. Gibson:[7] This is a cold weather discussion, but you have a great deal of warm weather in this city at the present time. We in the South possibly have a cold spell once every seven or eight years. I have been in Charleston 12 years and we have had two cold spells during that time, when it was below freezing. Our town is an old city that was founded in 1680. There was no waterworks in those days. There are a number of buildings, both frame and brick, which were constructed without any idea of ever having a water system installed. The home in which I now live was built in 1800. It was built with fire places and no basement. The water is within a couple of feet of the ground. In fact since we have lived there my boys have taken their mother in a canoe from the front steps and paddled all over that section of the city. That flood was due to an excessive rainfall, an inadequate storm water drainage, and a prevailing northwest wind which drove the water into the harbour and over the streets. In every six or seven years we will have a drop of temperature down to 18 degrees. The plumbing and the buildings are built with the idea of having porches on the south and west side because the prevailing winds in the summer time are from the southwest and they are the cool winds, and in the winter time that is the cold side of the house. All the plumbing is on the north and east sides of the house, and in many cases on the outside of the building entirely, because they do not want to cut up these old buildings as it would mar the inside. The frost occurs so seldom that it is just like the old question of the horse being stolen if you

[7] Manager and Engineer, Water Department, Charleston, S. C.

do not lock the stable. When we do have one of these frosts we have from 40 to 70 per cent of our services frozen up during one night. The next morning nearly every plumber in town will be out repairing pipes. We never have a frost that will go more than 2 inches below the surface, but if we have a drop in the temperature of from 40 to 20 degrees, we will invariably have from one to a half a dozen breaks and leakages in our main. I have never been able to understand why. I do not believe it is due to the freezing and expansion of the soil, because we do not have enough frost to create that, but invariably we will have from one to half a dozen breaks during such a period.

MR. MACDONALD:[2] In answer to Mr. Routledge's question about the expansion and contraction of the earth, some fifteen years ago we installed in Ottawa some street connections and during the first three years 10 of the 24 developed trouble. The expansion and contraction of the earth caused a movement of the connections which we located on the surface. Immediately next spring we removed the other fourteen and since that time these connections have been installed in the gate valve chamber.

In answer to the gentleman from Sudbury as to finding out when the hydrant is frozen, in Ottawa we have nineteen different makes of hydrants, all ranging in size from a 4- to one of 8½-inches in barrel. We have never been able to train our men sufficiently so that they could tell whether they were frozen by sound. We find the actual time of thawing is even less with the copper service, than with lead or iron. The type of machine we use is directly connected to a gasoline 40 h.p. motor operating on 25 volts, and generating 500 amperes.

HENRY P. BOHMANN:[8] There has been considerable discussion about the maintenance of hydrants, and I should like to bring up something with regard to the location of hydrants. If they are in the middle of the block we place them immediately back of the curb, and between the two dividing properties. In driving around Toronto I notice that in certain sections the hydrants are not placed back of the curb. They are placed on the property line and not on the dividing line. They are placed right on the owner's lawn. In one instance I noticed the man had it blocked off with stone and had ornamented it with flowers, and I have been wondering why they permitted them to have the hydrants on the lawn.

[8] Superintendent, Water Works, Milwaukee, Wis.

A MEMBER: The lawns in many cases extend beyond the street line. The hydrants are then on the lawn, but still on city property.

THE CHAIRMAN: Some men may be able to make devices that will get the echo back from the hydrant, but I would not care to use that method. We have our services about five feet below the surface and a number of them are in territory where there is no sewage or drainage, but we use extension dials and we have no trouble.

WM. W. BRUSH:[9] I was much interested in Mr. MacDonald's statement of how the operation of the water system in Ottawa is planned and carried out. I want to congratulate him on presenting a complete description of what seems to me to be a very efficient plant, and a well operated water works system. I felt a little encouraged when he said he had nineteen different types of hydrant, because from the paper I saw that Ottawa had a 100 per cent system in every particular, but I am glad to see he has some human trouble in the system. We may in New York have nineteen different types of hydrant, but generally speaking we have been remarkably successful in getting rid of different types of hydrant during the past twenty-seven years, since which time we have used only one type. Twenty-seven years ago it was suggested that we should standardize our hydrants, and at that time it looked hopeless, but I would advise those of you who have many types of hydrant, that you take them up one at a time, and do not worry about it. Although you may be dead before the complete change is effected, yet I have managed to live during the twenty-seven years and we are now pretty nearly down to one type in all our 50,000 hydrants.

Mr. MacDonald spoke about the control of the work of the different gangs. In our system I find very little value in trying to increase the efficiency of our gang, because I personally came to the conclusion that the only way we could increase the efficiency of our men is by securing a personal interest in their job. We have a very strong rule that we have to make charges against a man and prove them beyond doubt before we can dismiss him. In fact we had a man who committed murder, and it was almost impossible to get him off the pay roll, although he was declared criminally insane. Under these conditions you cannot do much in a disciplinary way. However,

[9] Chief Engineer, Department of Water Supply, Gas and Electricity, New York, N. Y.

if you feel that the personnel are interested in what they are doing, you need not worry about the results. If the men are intelligent enough and sufficiently skillful, their work will be satisfactory, if the personal interest is there. We try to plan our operations so as to magnify and increase the interest of the individual in his job. We try not to make our job a machine job, and even if we have a slight disagreement by trying to localize responsibility, we do not hesitate to do it because we believe in the end we get a cheaper and better job for the city.

Another important thing Mr. MacDonald is doing is having a twenty-four hour service at the central office. In any system that is large enough, and many of the systems are large enough to justify it, there should be somebody on duty at the main office during twenty-four hours of the day who can take charge of any situation that arises. I have not been able to get our officials to allow me the necessary funds to establish a twenty-four hour service at the central office. We have many gangs on duty during the twenty-four hours, and we have our engineers on emergency duty from the time they arrive at their homes until they leave the next morning, but that is not a satisfactory substitute for a man who is regularly assigned to duty at the office. I should be very much interested in knowing from Mr. MacDonald whether he has a man at the main office who is capable of taking charge of any emergency which is likely to arise, and also whether he has an emergency truck that is on duty during the twenty-four hours of the day.

Mr. MacDonald:[2] Yes, there are three men in charge at the head office, and they are men who have been trained in the engineering office. They were brought in as young men and they have a knowledge of the distribution system, and they are capable of going out and handling any emergency. They are occupied in drawing plans during the twenty-four hour period, and they work in eight hour shifts. In addition to that they receive from the purification plant and from the pumping stations every fifteen minutes a record of what is going on. For instance, in the disinfection plant it is essential to know that our chlorination plant is working, otherwise it might mean a serious outbreak of typhoid fever. Every ten minutes a report is sent in. We are working very close to the line, and the operator of the plant has to report to the central office and give the condition of the water. In addition, emergency trucks are maintained and

there are three men on duty throughout the night. One man can go with one of the small trucks to look after small repairs, and two men are constantly in charge of the other truck. In that way they have full control of the apparatus. We have also a fire alarm gauge in the winter season when the temperature is below freezing.

RESPONSIBILITY OF WATER COMPANIES FOR FIRE PROTECTION[1]

By Robert G. Gordon[2] and Paul Hansen[3]

The attitude of the courts in the States of Kentucky, Florida and North Carolina with references to the obligation of water companies for fire losses raises some interesting questions both in legal practice and water supply practice that may advantageously be considered by the American Water Works Association. These questions touch upon some fundamentals of contract law and on some fundamentals of the functions and limitations of a public water supply in fighting fires.

The attitude of Kentucky courts has its precedent in the case of Paducah Lumber Company vs. Paducah Water Supply Company, 89 Ky. 34, 13 S. W., 249, in which the court held that the water company did not maintain its contractual obligations because it did not furnish an adequate quantity of water for the extinguishing of the fire and, therefore, was subject to damage for fire losses. The right of action of a property owner is based upon the theory that the city has made a contract with the water company for the benefit of its inhabitants who are property owners. The case of the plaintiff rests upon his ability to prove that the water company has not lived up to stipulations in its contract with the city covering fire protection. Though plaintiffs usually strive to bring in charges of negligence, incompetence and willful injury, these elements have no valid bearing because the water company is not obligated to furnish fire protection to a private owner except by virtue of a contract made by the city on the property owner's behalf. Therefore, the question of guilt must rest entirely on the terms of the contract.

Most contracts between cities and water companies are negotiated under conditions that do not favor the most exact and scientific wording. Representatives of the city are apt to look askance at

[1] Presented before the Kentucky-Tennessee Section meeting, January 24, 1929.

[2] Attorney at Law, Louisville, Ky.

[3] Consulting Engineer, Chicago, Ill.

any reservations concerning fire protection and technical delimitations for fire protection service, hence the average contract is apt to require in sweeping terms that the water company shall furnish all the pure water that may be required or demanded at any and all times for public and private purposes and for fire protection.

Under such terms as these it is almost always possible to prove that a water company has not lived up to its contract and therefore liable for all losses due to a fire. The decision is adverse to the water company even though it can be demonstrated that reasonable quantity and pressure of water were actually available, and that with proper manipulation on the part of the fire department loss could have been avoided.

The injustice to the water companies that results under court decisions in Kentucky, Florida and North Carolina is due to failure to recognize that a public water supply is not a fire prevention device, but a fire fighting device. All water works men recognize that no water system, and especially none in smaller communities, can be made to furnish a volume and pressure of water that will positively insure the prompt extinguishment of any fire. On the contrary, it is possible for a great conflagration to get quite beyond the power of streams of water to extinguish it or even control its spread. This was clearly demonstrated in the Baltimore fire of 1904.

In the light of the foregoing it seems unreasonable, unfair and at times confiscatory to hold water companies responsible for fire damage.

On the other hand a water company should be held responsible for maintaining reasonable fire fighting facilities and should be subject to stipulated penalties should fire fighting facilities fall below those named in the contract.

As a guide to what constitutes reasonable provision for fire fighting, the general criteria of the National Board of Fire Underwriters may be used. These criteria must not be used blindly, however, but should be applied to the extent desirable and practicable under any given set of local conditions—financial as well as physical. By way of illustration, it may be well to review some of these criteria:

Six inch diameter pipe for street mains is the minimum size for good fire fighting in residence districts. This can in most cases be justified on grounds of long run economy because 6-inch pipe costs, in round numbers, but 35 per cent more than 4-inch pipe and has nearly three times the carrying capacity with the same friction losses. Where

rock bottom economy must be practiced and where houses are sufficiently far apart to prevent spread of fires, 4-inch pipe may be permissible. This recognizes the principle that water supplies are primarily for checking the spread of fires rather than for saving an individual house. Often the water itself does quite as much damage as the fire.

Dead ends should be avoided on the distribution mains and cross connections should be made at not over 600-foot intervals. The advantage of this is obvious, for where no dead ends exist and there are frequent cross connections, a flow of water may reach a fire hydrant

TABLE 1

POPULATION	GALLONS PER MINUTE FOR FIRE FIGHTING
1,000	1,000
2,000	1,500
4,000	2,000
6,000	2,500
10,000	3,000
13,000	3,500
17,000	4,000
22,000	4,500
28,000	5,000
40,000	6,000
60,000	7,000
80,000	8,000
100,000	9,000
125,000	10,000
150,000	11,000
200,000	12,000

from two directions, thus practically doubling the water available. Yet in some small towns and in the outskirts of some large towns, this may not be feasible or financially justifiable.

Table 1 shows the quantity of water which should be available for fire fighting purposes, for various populations. This tabulation clearly illustrates the impossibility of providing unlimited volumes of water for fire fighting. These quantities are liberal under ordinary circumstances and might be cut down for communities in which the fire risks and property values are not high. On the other hand where great fire hazards exist, such as lumber yards and inflammable industries, even larger quantities of water should be made available.

Fire hydrants should be located so that not more than 120,000

square feet are served by one hydrant. The reason for this is obvious. Local conditions may, however, warrant a greater distance between hydrants and, in any event, the intelligent placing of hydrants is quite as important as their spacing. Closer hydrant spacing as indicated by the Underwriters Manual will, of course, be necessary for districts of larger fire hazard.

Where fire pumpers do not form part of the fire department equipment, it is customary to raise the pressure on distribution systems. Contract requirements demanding a fire pressure different and higher than ordinary pressure is a fruitful cause of contention in litigation against water companies over fire losses. Often the locality and elevation at which pressures are to be measured is loosely indicated and the type of gage to be used is not stated. Rarely is anything said about pressures at fire hydrants under given conditions of flow. Generally speaking it is better for a city to provide itself with fire pumpers than to require the water company to have an ordinary and a fire pressure. Fire pressure is severe on plumbing and pipe joints. Increased leakage and waste when high pressure is on the mains prevents much of the water from reaching the fire. Drawing from the mains with a pumper tends to decrease leakage and waste and thus insures a maximum quantity of water being thrown on the fire. Fire pressure also prevents the utilization of elevated storage reservoirs.

Wherever possible, particularly in smaller cities, elevated storage should be provided. The water in such reservoirs is instantly available and not dependent on starting of pumps. When sufficiently large, no extra pumping capacity will be necessary and hence pumping may be carried on uniformly and at maximum economy.

It would be possible to enumerate and discuss many other details of a water works system that influence fire fighting, but enough has been said to illustrate the point that the fire fighting capacity of a water works is always limited, that it can in no case prevent fire damage, and that fire fighting capacity can best be provided by stipulating in the contract the nature, arrangement, sizes and capacities of various component parts of a water works system.

DISCUSSION

F. C. Dugan:[4] This paper is a result of conference held between Messrs. Clark, Hansen and myself. It seems that Kentucky is one of the states where water plants are responsible where excessive

[4] Chief Engineer, State Department of Health, Louisville, Ky.

damage has resulted from fire. I asked Mr. Hansen to prepare the technical side of this question and Mr .Gordon the legal. Mr. Gordon was taken ill and was unable to carry out his part. Mr. Hansen wrote me that he hoped the discussion here would be full on this subject and that it could be sent to Mr. Gordon and himself so that they could prepare a thorough discussion on this subject.

JAMES SHEAHAN:[5] What does the Kentucky Court consider an adequate supply of water?

ALBERT CLEMENS:[6] It is difficult to say just what would constitute an adequate supply of water. What would be considered more than adequate in one instance would, in another, be negligible.

Based upon the principle that water supplies are primarily for checking the spread of fires, it would seem that the sooner the water is applied after the fire has started, the smaller would be the amount of water needed to extinguish it, and vice versa. Of course, much would depend upon how the water is applied, so that under certain combinations of circumstances, including the human element, a water supply may be considered adequate.

By way of illustration: Last year in Shelbyville, Kentucky, two adjoining dwellings were completely destroyed by fire at 8:00 o'clock in the morning, after the fire department arrived at the scene, while only a very small area of one of the dwelling roofs was involved.

There were three fire hydrants within easy reach of these dwellings, two of them on 6-inch circulating mains and the nearest one across the street on a 4-inch circulating main.

The department responded promptly and connected their pumper to the weaker hydrant. For some reason they were getting less water than could be expected from a 4-inch circulating main, and, to make bad matters worse, instead of conserving the weak supply for one stream, they laid off two lines rendering both streams ineffective. During all this time, reliable witnesses claim, the fire could easily have been extinguished with one small stream had the hose been carried up into the attic.

After the first house was a total loss and the second one considerably involved, a line was finally laid to the farthest hydrant about 500 feet (the next nearest one being overlooked) and a good hydrant stream was obtained which eventually stopped the fire.

[5] Superintendent, Water Works, Memphis, Tenn.

[6] Louisville, Ky.

The records show that at the time of the fire the domestic pressure in the system was 70 pounds which was later increased.

As the result of this fire, the water company was sued by the owners of the property on grounds that they did not furnish an adequate supply of water.

In our opinion, there was an adequate quantity of water available at any stage of the operation had proper use been made of it, for it subsequently developed that even without the pumper a hydrant stream was used to extinguish the fire after it had gained much greater proportions.

We are, therefore, inclined to believe that adequate water supplies are as often rendered inadequate by inefficient use as efficient and earnest effort on the part of the fire department is made useless, by inadequate water supply.

James Sheahan:[5] There must be some reason if a plant is not equipped to take care of a fire. My understanding is that a plant is built 60 per cent larger to take care of fires. I think it should be told whether it is lack of carelessness, inadequate mains, or what. If the city furnishes enough water it might be due to some other cause. I cannot see how any court can decide without first investigating the direct cause. Any city is foolish to give damages for fires. We do not assume any responsibility for damage in our contracts. Kentucky should do the same thing.

W. S. Cramer:[7] In a great many cases the difficulty is due to defective hydrants. In one case it was claimed that the hydrant was frozen. It was really turned the wrong way and jammed. The suit was carried into the court and we won the case, but the suit was based on the fact that the hydrant was frozen. In one other suit that we had it was claimed that the hydrant was in bad condition and the stem broken. The law in states in which I work provides for an adequate supply of water and a penalty if it is not available. In most cases water is taken from the pumper to the fire and we have very little trouble with fires. With a triple hookup there is no noticeable delay. We have had only three suits—two cases we won—one case took court appeal and afterwards our lawyers compromised.

[7] Vice-president and Manager, Lexington Water Company, Lexington, Ky.

W. H. LOVEJOY:[8] Does your Company have any sort of contract with the city?

W. S. CRAMER:[7] Yes, on stream requirements and supply for direct fire pressure.

L. S. VANCE:[9] I think what Mr. Hansen and Mr. Gordon wanted to bring out was that the law in the state is primarily against the water company. It is up to the water companies in the state in making contracts and obtaining franchises to bear in mind these states' attitude on this question and protect themselves against the worst possibilities, as they cannot wait until such a time when laws have been enacted which are fair to the water company.

The water company should be able to supply cities with the amounts mentioned in Mr. Hansen's paper.

W. S. CRAMER:[7] We have had suits and are always afraid of slip-ups. I wonder if the members here have run into the same trouble we have. We found hydrants that had been bumped into and broken off evidently by automobiles and showed no leakage around the hydrant. If that hydrant had been used by the fire department it could have caused quite a delay and possible damage. Who would be held liable?

W. H. LOVEJOY:[8] You would probably be held liable.

A. F. PORZELIUS:[10] We have had that case in our plant here. However, the city is responsible for fire hydrants and as a result they make periodic inspections of fire hydrants. Of course, they could not place the responsibility on us and we have never had any suits since the city is responsible for these hydrants. I can see how one could get into predicaments where automobiles run up against hydrants, but hydrants should have continuous inspection. We have more or less trouble with contractors. The rule is that they get a permit from the city to use water and use a portable meter. However, they do not always do this. It is more of a legal matter in Kentucky. I think you should get some good lawyer to ascertain what is meant

[8] Superintendent of Filtration, Louisville Water Company, Louisville, Ky.
[9] Louisville, Ky.
[10] Superintendent, City Water Company, Chattanooga, Tenn.

by an adequate supply of water, by responsibility for leakage of hydrants caused by automobiles, etc.

Beekman C. Little:[11] If the water company fights against this ruling which allows a person to sue or collect damages as a result of fire, it seems to me that they should stress that the water company is not responsible for fires. I know the Insurance Underwriters are hammering away to get us to put in larger mains, services, etc., and they have put us on the defensive in the public eye. Water supply never caused a fire and I do not believe it ever will. Investigations should be made not on whether the water supply was adequate, but as to the actual cause of fire.

W. S. Cramer:[7] A case in point is where a very ordinary cottage district is turned into a mercantile one by the erection of a large tobacco warehouse. While with us the stream requirement is not changed, yet we are blamed generally for not having an adequate supply for fire purposes.

A. F. Porzelius:[10] In connection with repairs, we always call the fire department and notify them. In case they do have a fire in that district they know they cannot use those hydrants. Having the knowledge in advance they are not handicapped, but just have to lay a little more hose. I do not believe any court could hold a water company liable if you have done everything possible to repair the main.

W. S. Cramer:[7] In the Paducah case the hydrant which was broken and the breaking of same was the foundation of the suit. It was broken by a city street hand and so admitted by him in court, but it was ruled that inasmuch as the company allowed the use of the hydrant by the city employee he became the company's agent and they were responsible for his acts. This is another reason for not allowing the use of fire hydrants by any but firemen and for extinguishing of fires.

H. N. Old:[12] It appears that court decisions throughout the states are quite common by which the municipally or privately owned

[11] Secretary, The American Water Works Association, New York, N. Y.
[12] Sanitary Engineer, United States Public Health Service, Memphis, Tenn.

water works are held liable for the transmission of typhoid fever by contaminated water furnished consumers, where negligence has been satisfactorily proven. Therefore, it is reasonable to expect that such decisions based on quality of water would also extend to inadequate quantity which has caused excessive fire loss, where the defect can be traced very definitely to actual negligence.

W. S. Patten:[13] I understand that, if a company is installing gate valves, it is responsible for closed hydrants, etc.

W. H. Lovejoy:[8] This responsibility has never been tested in the courts.

[13] Manager, Ashland Water Works, Ashland, Ky.

CEMENT FOR CAST IRON PIPE JOINTS[1]

By O. G. Goldman[2]

Cement was first used on the Pacific Coast for making joints in cast iron water pipe some forty or fifty years ago at San Jose and Redlands. A little later Los Angeles tried it, but not until 1911 did the cement joint come into common use. Long Beach was probably the first to use it extensively, closely followed by Los Angeles. Portland, Oregon, followed in 1916, San Francisco in 1917 and other cities at about the same time.

In San Francisco we have had the joints in service for as long as twelve years under an average pressure of about fifty and a maximum pressure of over one hundred and fifty pounds. We have lines with cement joints laid alongside of heavily traveled street car lines, under street car tracks, railroad tracks and under all conditions ordinarily found in a rather large distributing system. The joints have proven entirely satisfactory. They have stood settlement, vibration and shock as well as lead joints in the system.

There are two disadvantages to cement in pipe joints. It is not easily removed and time must be allowed for the cement to set before the line can be filled with water. The first objection is not serious as but few joints have to be replaced. When necessary the cement can be chipped out, using a long chisel. An eight inch joint can be cut out in twenty minutes. One day is usually allowed for the cement to set, although we have successfully turned water into a line in which some of the joints have been in place only from five at night until eight in the morning, fifteen hours. Lead is used in making connections to the existing mains, since it is necessary that the water be turned on within a very few hours.

Making cement joints is simple. The pipe is placed in the ditch, spigot in bell, the same as for lead joints. The caulker is equipped with a pail of water, a portion of a sack of cement, yarn, a flat pan

[1] Presented before the Plant Management and Operation Division, the Toronto Convention, June 27, 1929.

[2] Assistant Superintendent, City Distributing Department, Spring Valley Water Company, San Francisco, Calif.

about twelve by eighteen inches, a small trowel, yarning iron, a set of caulking tools and a pair of gloves. The gloves used by us are of cotton and are simply for protection to the hands while handling the cement. The caulking irons are the same as for lead except that one extra tool, more like a yarning iron than a caulking tool is carried, to be used in ramming the cement into the joint. The point of this tool is six inches long, one inch wide, and one quarter inch thick.

The caulker first yarns the joint. For a while we soaked the yarn in water or grout, but later discontinued this as the dry yarns gave a firmer backing for caulking. Next enough cement for one joint is put in the pan and spread. This cement is then sprinkled with water, and thoroughly mixed, using the trowel. When ready for use the cement should be wet enough to mold and yet dry enough to crumble when dropped a distance of twelve inches. At first both cement and water were measured, but the measures were soon discarded. The sprinkling is done with a piece of yarn kept in the water bucket. The caulker then places the pan under the joints to be made, takes a handful of cement, always using a gloved hand, and with a cupped hand holds it up against the joint opening. With the cement caulking tool he then forces the cement into the opening, moving the hand around the joint opening until it is about half full. This cement is then caulked as hard as possible, the joint refilled and recaulked until the cement is about flush with the face, no bead being put around the outside. The amount of caulking for a cement joint is about the same as for a lead joint.

When water is turned into the line the joints will at first weep, sometimes rather badly. Unless too poorly made they will take up and become absolutely tight. A very poorly made joint may have to be cut out and replaced. Sometimes lead wool is used to stop the leakage. With experienced men we rarely have to resort to this expedient.

When laying 4-, 6-, or 8-inch pipe only one caulker works on a joint; for larger pipe two men work on a joint, each starting at the bottom and working up one side to the top.

A man can make sixteen 8-inch joints in a day, other sizes in proportion. The cement used is about one pound per inch diameter. This includes normal loss.

The main reason for using cement for the joint material is the cheapness of the material, the labor cost per joint being approximately the same as for lead. There is, however, another advantage

to the use of cement as the jointing material, in that it produces an insulated joint, thereby assisting in protecting the mains against electrolysis, although this is not an important factor in cast iron pipe.

It might not be amiss to state at this time, that cement joints are placed in steel mains, simply for its insulating value. A complete insulating joint consists of three sets of cement joints, separated from three to four feet. The joints are made by using steel bands 12 inches wide and 1 inch larger in diameter than the outside diameter of the pipe, the end of the pipe being inserted under each band 4 inches. The area between the pipe and band is then filled with pure cement hammered into place, similar to those made for cast iron pipe; the distance between the two ends of the pipe under the bands being filled with a wooden form which is removed as soon as the joint is finished. This type of insulating joint should not, however, be used on steel mains where any amount of surging or water hammer is liable to occur, as the joint is soon destroyed, the reason for this being that the cement ring is rigid compared to the steel main, and cracks badly after the first surge or so, thereby causing the joints to leak.

An excellent article on cement joints by Clark H. Shaw is in volume 83 of the Transactions of the American Society of Civil Engineers. Other articles on the same subject are; by George W. Pracy in Volume 7 of The Journal of the American Water Works Association; by William Wheeler in Volume 37 of the Journal of the New England Water Works Association; and by William Henderson in Volume 44 of Gas Age.

COPPER TUBING FOR UNDERGROUND SERVICE LINES[1]

By P. B. Andrews[2]

During the past five years hundreds of water works engineers, superintendents and commissioners have investigated the use of copper tubing for underground services and have adopted it as standard for this purpose. Such well known and efficient water departments as Baltimore, Scranton, Syracuse, Cincinnati, St. Paul, Minneapolis, St. Louis, Omaha, Oklahoma City, Dallas and Los Angeles, have seen fit not only to include it in their list of standard materials, but also to insist upon its use. Quite a large number of smaller cities have followed the same practice and we find several cities and towns in our own state of Illinois already using copper tubing. Obviously this kind of material must have some distinct advantages or economies that would be of interest to all water works men.

Briefly, a complete service, using copper tubing, consists of the necessary corporation stops, curb stops and fittings; so designed as to provide for a flanged or flared compression joint, much on the order of the tube joints used on the more familiar gasoline lines of your motor car. These fittings make possible the use of a specific size of thin wall pure copper pipe or tubing. The object of the design and fabrication of the pipe and fittings is to make a thoroughly reliable complete water service with as high a copper content as possible and at a cost that will permit its general use.

One naturally wonders why the pipe should be made of pure copper and why the fittings should contain just enough alloy to permit them to be machined into their proper shapes. The answer is that copper is the only commercial metal that will not corrode and disintegrate over a period of time under ordinary soil and atmospheric conditions. In short, copper is probably the greatest time-defying metal known to man, and, in this age of rapid development and exploitation of inferior and cheaper metals, one is apt to forget that copper is man's oldest and most reliable material.

[1] Presented before the Illinois Section meeting, May 13, 1929.

[2] Mueller Company, Decatur, Ill.

Copper has been used a long time. It was the first metal used by ancient man. It is estimated that pre-historic people began to change stone implements to copper some ten thousand years ago. They found copper in an almost pure state, resembling rocks, and from these fragments they learned to fashion, by cutting and pounding, crude axes, knives, and other weapons. It was over two thousand years later that these ancient people learned how to melt copper into different shapes rather than to pound or cut it.

Findings of archaeologists point that copper was first used in the valley of the Euphrates River. With the spread of knowledge copper was used all over the ancient world and traces of the handiwork of the people at that time are still being found in Egypt, Mesopotamia, India, China, Europe, North and South America and Australia. Findings have proved that copper was used for three dynasties before the three great pyramids were even planned. The pyramids were built somewhere between 4100 B.C. and 3800 B.C. A section of copper pipe was actually dug up at Ghizeh near the tomb of King Sahoure and is still in a perfect state of preservation after an interment of approximately 5700 years.

It is hard to conceive the number of ages elapsing between the discovery of copper and the development of bronze and brass. Bronze was developed about 4200 years before Christ and brass not until about 1000 B.C. The name of copper itself is directly traceable to the ancient Latin word "cyprium" which, after much use, was called "cuprum." The German word for copper to this day is "kupfer."

Inasmuch as copper is the oldest known metal, and has been used wherever enduring quality is desired, we can safely accept it as the most durable of metals without the necessity of explaining the electrical and chemical actions or reactions of corrosion in order to prove it, or without adding anything to the voluminous evidence already collected.

The exploitation of iron and steel during the past hundred years has placed those metals to the front for many uses. Iron pipe has become so common that we forget that it was only a few years ago that hollow logs were used for water conduits. Manufacturers of brass and copper pipes found it increasingly difficult to meet the competition offered by a natural resource so plentiful and easily mined and manufactured as iron. In order to be thick enough to receive the impressions of standard iron pipe threads, the copper, brass and bronze pipes were so expensive, compared with iron

and steel, that it was only in extreme corrosive environments that these non-ferrous metals could be used profitably for piping.

It was to solve this problem that copper tubing was introduced as the ideal water supply pipe. Knowing that the walls of pipe were unnecessarily heavy, except where they are threaded, it was concluded that if a suitable joint could be found to take the place of the standard iron pipe joint, copper tubing would be acceptable. With this thought in mind every conceivable pipe joint was investigated, tested and tried out, but none could stand the rigid requirements of the perfect underground service. It was from the small S. A. E. automobile gas line fittings that the idea of a compression joint was conceived. After much designing a compression fitting was made strong enough to be considered reliable.

Naturally these fittings were made of copper with just enough alloy in them to permit their being accurately machined and to have sufficient tensile strength.

When a suitable connection had been designed and developed and standard sizes and weights of a suitable grade of copper tubing had been perfected it was found that an underground water service made of this material possessed other qualities than that of just endurance.

A perfect underground service pipe should measure up to the following qualifications:

1. Both the pipe and connecting fittings should be of sufficient strength to withstand the internal and external pressure exerted on them without showing weakness or defects.

2. The entire service line should be flexible and elastic enough to withstand the sudden or gradual shifting and settling of the soil in which it is laid, or, the settling of the building or structure to which it is connected, or in which it is installed. It also should be flexible enough to take up the mechanical variance of installation.

3. The cost of the material should be low in accordance with all other necessities of life and the cost of installation should be reduced to a minimum and should not require expensive tools or operators.

4. The nature of the assemblage of the pipe and fittings should be such that they can be taken apart and placed back in service with slight or no loss of material. Its salvage value should be in ratio to the difference between the initial cost and the service rendered.

5. The material should successfully withstand, or ward off, the attacks of chemical and electro-chemical corrosion found in the environment of most pipe installations.

How copper tubing meets these requirements will now be discussed.

Whether or not the tubing will withstand the pressure of the water which it carries, is illustrated by tests on fifty samples of three sizes. The following bursting pressures on copper tubing were obtained in pounds per square inch.

Size, inch	*Bursting pressure*
$\frac{1}{2}$	6,120
$\frac{3}{4}$	4,815
1	3,890

It was particularly noticeable in the tests on the bursting pressures of copper tubing that the fittings which were used with them did not leak or show any signs of weakness or defects.

Comparative bursting pressure tests were run the same time on other forms of service pipes, but owing to the stretching properties of pure copper other pipes, although withstanding heavy pressures, did not equal the marks set by the copper tubing.

Another interesting test was conducted on copper tubing to determine its relative resistance to bursting from the initial expansion of frozen water. A number of specimen sections of copper tubing were filled with water and frozen. The ice was taken from these specimens and the pipe refilled and frozen again. These operations were repeated until the pipe burst. Most of the sections of copper pipe withstood seven repeated freezings without bursting, while one section withstood twelve repeated freezings.

Comparative freezing tests were also conducted on other pipes with results not nearly so satisfactory as those obtained by the copper tubing. In both the hydrostatic bursting pressure tests and the freezing tests the metals in the various pipes showed their respective qualities under stress. Iron pipe held firmly until sufficient strain was placed upon it and then it parted readily without any perceptible preliminary stretching. The lead pipe stretched and flaked, at the same time showing that the metal was crystallizing and gradually falling apart. The brass pipe stretched a trifle owing to its copper content, but because of the inability of tin and zinc to stretch in proportion to the copper, the brass gave way under pressure. Copper alone held up to the same strain which caused the other pipes to burst. Its percentage of elasticity was inverse to the cumulative strain placed upon it, as it is the nature of this material to harden slightly under stresses.

Copper tubing, being naturally softer than ordinary pipe, was thought by many to be easily mashed and subject to collapse while in service. To clarify this point a severe test was conducted to illustrate its resistance to shearing or flattening.

A length of $\frac{3}{4}$-inch copper tubing was laid across the edges of two beams, spaced 5 feet apart, and held in position by the flanged fittings at either end. Upon the beam and on top of the pipe twenty sacks of Portland cement were piled aggregating 2000 pounds or one ton dead weight. An air vibrator was attached to the test frame which had approximately 1200 vibration alternations per minute. This was to accelerate the pressure exerted by the dead weight on the pipe, corresponding with extreme cases of traffic vibration on underground service lines resting on or against sharp rocks or boards left in the street.

The severity of this test is explained by the fact that the pipe had no support beneath it and that the weight was continuous and could not slide off as dirt would in a trench. The supporting beams had sharp right angle edges that were made of hard pine lumber. This would naturally tend to shear a soft pipe in two. Furthermore, the vibrator ran continuously and not intermittently as would be the case with traffic on the surface of the ground.

A city water pressure of 40 pounds per square inch was in the pipe during the entire test and at no time did the pipe leak or show any retarded flow of water. The pipe sagged a total of $8\frac{3}{4}$ inches, giving it an elongation of 3.75 inches per foot. At the point where there was a tendency of the pipe to shear off and collapse the copper tubing had only a 10 per cent reduction of area.

The internal pressure, freezing and collapsing tests have demonstrated that copper tubing is sufficiently reliable for the requirements of a water service pipe.

We shall now consider the second essential requirement of a perfect water service pipe, that is, the entire service line should be flexible and elastic enough to withstand the gradual shifting and settling of the soil in which it is laid; or the settling of the building or structure to which it is connected, or in which it is installed. It should also be flexible enough to take up the mechanical variance of installation.

The extent of underground pipe for water, gas and drainage in any given district is in direct proportion to the population of that district. Their importance to sustaining life and comfort may also be gaged by their size and number. We find, therefore, in rural districts rela-

tively few underground pipes and even these could be dispensed with, upon their failure to function properly, without vitally affecting the life of the community. On the other hand, in the congested districts of a modern city we find a maze of underground pipes that are truly labyrinthian in their extent and the failure of any one section of them would materially affect the comfort and lives of a great number of people. This multiplicity of pipes, coupled with large sewerage systems, necessitates the loosening up of the soil for their respective installations. The soil turn-over is of course greater in streets having subways, tunnels, or which are adjacent to large structures with deep underground foundations. Consequently, due to the tendency of the disturbed earth to settle to lower levels, we find the hazards of pipe installations increase with the number of installed services, with a corresponding danger to the population that requires this large number of pipe installations.

Where there is a danger of the soil settling we find three types of small water service pipes connecting the main to the consumer. They are, namely, lead and iron, all lead and copper.

In the first instance the ability of the service to conform to the settling of the soil is limited to the length of the gooseneck, which, although hardening by crystallization really stretches, but flakes off in particles, damaging the exterior or internal surfaces of the lead. Again, the gooseneck proves of no avail in the event of the soil settling on the iron pipe at a distance from the lead, throwing stresses on the iron pipe threaded joints which they cannot withstand. Because of its brittleness, iron pipe usually yields at the joints to the pressure of settlement and if the pipe does not break, the fittings loosen or become entirely disconnected. Especially is this true where the pipe is found weakened by corrosion. If the iron pipe should be soft enough to bend slightly, its inside diameter will greatly decrease and new surfaces will be exposed to the attacks of rust.

Where considerable soil settlement was expected complete lead services have been installed with results varying in success. In these cases double extra strong or triple extra strong lead pipe is used, which, because of its thickness, is quite expensive. As already pointed out lead weakens with each disturbance which shortens its period of serviceability. Where ground settlement brings lead pipe to bear on other pipes or on large stones or timbers the pipe is subject to shearing completely in two, or flattening beyond serviceability.

Copper tubing is now installed in many sections of the country sub-

ject to shifting or settling soil. Due to its flexibility there has never been a report of the failure of this material from inability to conform to such settlements.

To illustrate the elasticity of copper tubing, a large suburb in California was being developed and having a very efficient city ordinance they installed their water service lines first up to the lot line. In advance of the paving machinery the Californians have a machine known as a root puller which moves along the street pulling up roots so that the earth can be easily excavated. As the water services are laid close to the surface of the ground the root puller naturally pulled up many copper services to a height of about four feet. When it was discovered that it was a copper service pipe they had on their puller they would simply bend the pipe back down into the ground and continue their course, saying nothing about it. The copper pipe easily stretched the required amount without damage to the water service and no one, with the exception of those who witnessed the incident, knew anything about it.

The advantages of having a flexible service pipe are obvious as it can be bent by hand over and around obstructions which would necessitate special fittings with almost any other pipe, with the exception of lead.

The cost of a service pipe material should be low in accordance with all other necessities of life and its cost of installation should be reduced to a minimum and should not require expensive tools or operators. This is the third requirement of a perfect water service pipe.

The cost of copper service installations is naturally higher than of ferrous pipes. However, there are savings to be found on such installations in years of service. Water works distribution systems should be laid with the idea of permanency. This is especially true in this age of thicker and heavier pavements where it is becoming increasingly expensive to cut through to replace worn out or broken water services. Figuring costs over a period of time one may easily recognize the economy of using pipe that will not rust or disintegrate.

The fourth quality conceded for the perfect water service pipe is that the nature of the assemblage of pipe and fittings should be such that it could be taken apart and placed back in service with slight or no loss in material. Its salvage value should also be in ratio to the difference between the initial cost and the service rendered.

It has been pointed out by some that, when copper tubing is disconnected, it would be necessary to destroy the coupling nut and the

adjacent few inches of pipe because of the flanged joint. This is entirely erroneous as the brass fittings can readily be unscrewed with the same tools used to put them together and tests have proven no perceptible change in their size or structure. I have personally seen the same copper tube fitting unjointed and joined together again twenty-five times and each time it successfully withstood pressures exceeding 1000 pounds per square inch.

Copper tubing is easily installed and requires few rules or tools. The necessary tools are, hack saw, knife or reamer, flanging tool, and hammer. The rules are as follows:

1. Cut the tubing with hack saw to the length desired, taking care to cut at right angles.
2. Reàm the small burrs left by the hack saw on the inside and outside of the tubing.
3. Place a coupling nut on the pipe.
4. Insert a flanging tool.
5. Strike the exposed end of the flanging tool with the hammer, turning the pipe a little after each blow.
6. Remove the flanging tool and connect the coupling, pulling the nut up tight.

Since copper does not corrode like iron or crystallize like lead it is practically as good as new when removed from the average pipe installation after a period of service covering many years.

The fifth requirement of a perfect water service pipe is that it should successfully withstand chemical or electro-chemical corrosion found in the environment of most pipe installations. Upon reflection you will agree that this is a large order.

Rust is nature's method of reclaiming the metals which man so laboriously takes from the earth. It changes iron and steel back to their oxides, sulphates and other compounds much on the order they are found in nature. Copper also corrodes, but because most of its salts are not soluble the corrosion thus formed is an accumulative corrosion that serves to protect the metal against destruction.

It would be foolish to say that any material will stand up under any and all conditions. While copper tubing has been accepted by many water works engineers as excellent material for service pipes, there are also installations where the use of copper would be a failure. Like all metals copper is susceptible to acid attack. The most common acid encountered in the ground is a dilute sulphuric acid caused by surface waters seeping through cinders. In such cases good results

have been obtained by coating the copper tubing with an asphalt or coal tar paint. Most soils, however, are alkaline in nature, or contain enough alkali to neutralize acidity.

Recognizing the fact that no material is the "cure all" for all troubles, L. I. Reinicker, Kentucky State Manager for the North American Water Works Corporation, Lexington, Kentucky, says that: "The use of seamless copper tubing for water service pipes is now generally recognized as being not only practical, but also the nearest approached to a perfect water supply pipe."

PURCHASED POWER FOR PUMPING STATION OPERATION[1]

By T. R. Hughes[2]

With the development in the last five years of central station power plants, generating electric energy at high efficiencies, and the increase in reliability of this power, due to the interconnection of the various transmission systems, the advantages of using purchased power for the operation of small pumping stations are becoming more significant. These advantages are being generally realized now. Operation with purchased power means a minimum of investment, a minimum of labor cost and a relatively high operating efficiency for small units. Compensating for these economies the cost of energy is usually somewhat higher than the cost of coal.

To gain some picture of the size at which the steam plant no longer becomes the most economical for operation, I have plotted a curve in figure 1. This shows the total cost of pumping station operation, fuel, operating labor, maintenance and miscellaneous supplies, per water horse-power hour developed compared with the average water horse-power load on the plant. The term "water horse-power" is, of course, the brake horse-power required to drive a pump of 100 per cent efficiency. The cost of pumping per water horse-power hour is a particularly significant figure, both because it is a unit of work and because it may be readily visualized when it is considered that the overall efficiency of the average motor driven pumping unit is in the neighborhood of 75 per cent. Therefore, one water horse-power hour may be roughly considered as equivalent to 1 k. w. h.

The figures shown are all (except No. 14 which represents a carefully prepared estimate) taken from operating records of plants actually in operation and represent results being obtained. The only correction made to them was to reduce coal to $3.50 per ton. They are all fully comparable. The figures represent, with the exception of No. 13, plants operating reciprocating pumps, water being measured by plunger displacement. Actual water measured would

[1] Presented before the New York Section meeting, May 3, 1929.

[2] Mechanical Engineer, American Water Works and Electric Company, New York, N. Y.

be less and cost per water horse-power hour more than shown. With any centrifugal pump where water is metered economy will be correspondingly increased.

In figure 1 it will be seen that, with a plant as large as 650 water horse-power, the cost per water horse-power hour is $\frac{3}{4}$ cent. With a plant of 25 water horse-power average load, the cost of pumping is 4.8 cents. Both of the plants considered are operated by steam. Obviously the 650 h.p. plant cannot be operated more economically by purchased power. There are very few rates for energy at less

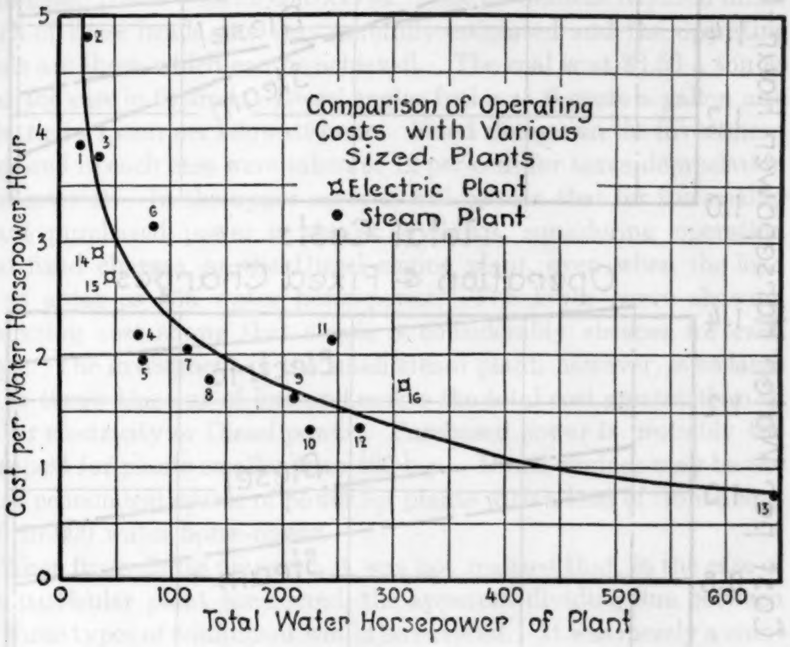

FIG. 1

than 1 cent per kilowatt hour. To this must be added labor and miscellaneous operating costs. On the other hand with an average load of 25 water horse-power, it is probable that power could be purchased for about $1\frac{1}{2}$ cents. Labor would be less than that required to operate a steam plant, and it would appear probable that this station could be operated more economically with purchased power. From a point of view of operating cost alone, it would seem probable that electricity would prove more economical on the plants smaller than 100 or 200 water horse-power.

Two points are also shown in figure 1 which represent the operating cost of plants operated on purchased power. The electric plant of 44 horse-power size, No. 15, is operating more cheaply than the steam plant of that size would. This means that not only is the cost of

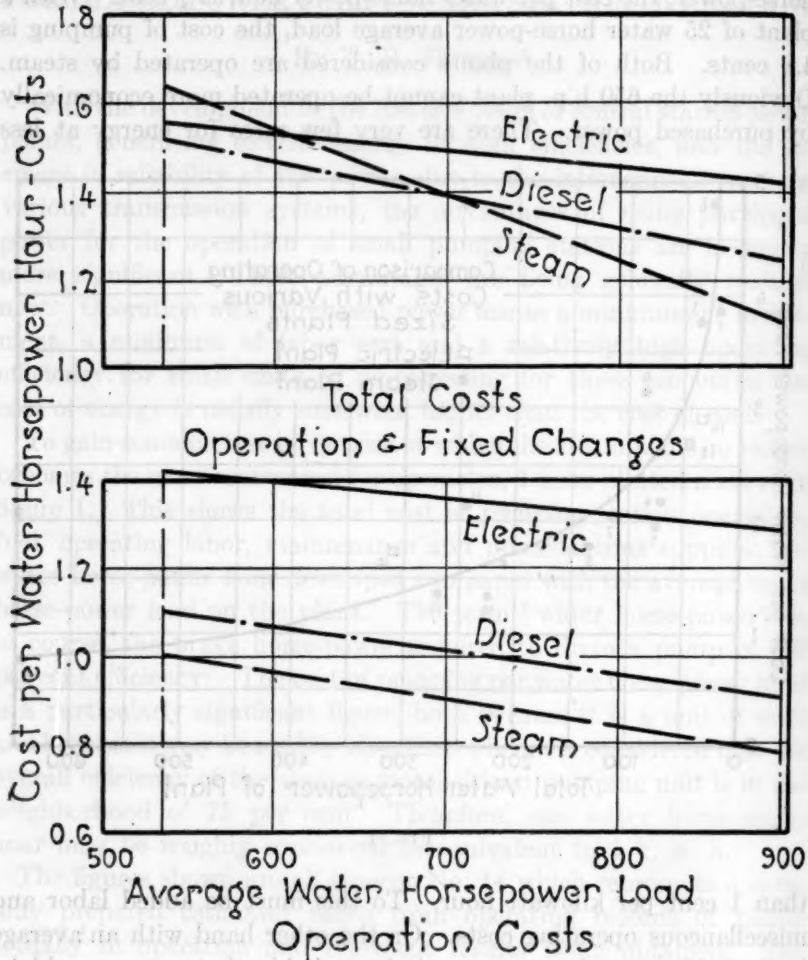

FIG. 2

operation of this plant less than the cost of operation of a steam plant, but also considerable saving has been made in the investment required to build the plant. The 310 h.p. plant, No. 16, operated by purchased power, costs somewhat more to operate than one of equiv-

alent size operated by steam. This, therefore, is approaching the point of demarcation between the economical electric and the economical steam plant.

Figure 2 shows comparative costs for both operation and fixed charges of various types of plants. It is a study of a plant starting with a load of 535 and growing to one with a load of 890 water horse-power; that is, it would be a plant pumping an average of 15 m.g.d. against a head of 203 feet and would grow to a plant of 25 m.g.d. against a head of 203 feet. In this study steam, Diesel engines and purchased power were all considered. The investment required under each of these heads was very carefully estimated and the operating costs are those which can be achieved. The coal is at $3.50 a ton as was the case in figure 1. Diesel engine fuel is at 6 cents a gallon and electricity 1 cent per kilowatt hour. Fixed charges on the investment required in each case were taken at 12 per cent for taxes, depreciation and interest. In the upper curve it will be seen that for the smaller plant purchased power is almost as cheap, considering operation and fixed charges, as the Diesel engine plant, even when the load is as great as 535 water horse-power. The lower curve showing operating cost shows that steam is considerably cheaper for each case. The investment in the small steam plant, however, is so large as to throw this out of line and makes the total cost greater than of either electricity or Diesel power. Purchased power is probably the cheapest for plants smaller than 400 h.p. Diesel engines may be the most economical source of power for plants with a load of from about 400 to 600 water horse-power.

When figure 2 was prepared, it was not realized that, in the case of the particular plant considered, the apparent dividing line between all three types of equipment would be covered. It was merely a coincidence that due to the loads chosen this was the case. The figures, unfortunately, all represent estimates. These curves and generalizations drawn from them are made, not with an idea of laying down any hard and fast rule, and saying to the water works designer that he can always save money, if building a plant whose average load will be 200 water horse-power, by operating it on purchased power, or that he will always save money by building a 400 water horse-power plant and operating it by Diesel engines. The curves can only be used to draw certain general conclusions and point the direction in which the most careful study should be made for plants of various sizes.

The plant studied in figure 2 was one which has a relatively high

load factor. A plant which has a very low load factor would probably show greater relative economies due to purchased power than the one considered here due to saving banking losses and the like.

Where a plant pumps into a large reservoir with constant load and ample reserve, all the advantages are in favor of purchased energy. In the case of the very small plant with some storage in the system, automatic operation may be used and almost all labor eliminated. In some cases it may prove desirable partially to electrify the plant. Where some existing steam equipment is economical this may be the case, either using the steam for base load or for peaks as may best suit the conditions. The partial electrification of a plant has the double advantage of reducing the cost of duplication of electric power, should it be necessary, to a minimum and also holding a convenient club over the head of the power company to keep them from raising the rates after they think they have secured their customer, since it is always easy to go back to the steam plant if they prove unruly.

The most difficult condition under which purchased power may prove economical is the case of an existing steam operated plant of small size which is to be converted to an electric plant. The only excuse for the electrification is that the total cost of the electrified plant, both for operation and fixed charges on the equipment required for electrification, will be less than the cost of operation of the steam plant. It may be easy to show that the cost of operation of a plant run on purchased power is cheaper than one run on steam power. When, however, we have to pay fixed charges on new equipment out of this saving, it very rapidly evaporates. Although the power companies frequently point out the large savings which may be effected by the electrification, it is frequently difficult to justify this procedure when one must make considerable investment.

The maintaining of a high operating efficiency when the energy cost for the plant is high is important. If a plant is being operated on purchased power, it is highly important that care be taken in the selection of pumping units in order that the efficiency may be as high as possible during normal operation.

One installation from which we have very good data on operating results shows that for 12 months the average operating efficiency of unit no. 1 in this plant was 66.7 per cent. Under test conditions and at exactly the right head this unit had an efficiency of slightly more than 70 per cent. It is a constant speed unit and the head varies

as much as 10 per cent above and below the average which, of course, cuts into the operating efficiency. Unit No. 2 in this plant had an average efficiency of 72.7 per cent for 12 months with a test efficiency of about 77 per cent. Unit No. 2 is operated by a variable speed motor, and the efficiency, of course, is low at any time at which the motor is run below full speed. These two units pump into a system which has very little storage and, therefore, the pumpage rate has to follow the demand closely and the system is subject to wide variations in load. In spite of the exacting load conditions and with only two units installed, the pumps operated within 6 per cent of their original guarantees. The figures are based on average heads obtained and, therefore, are not absolutely correct.

In another plant at which four units are operated, the average efficiency of the four units on test is 64 per cent. The average operating efficiency for 12 months of these four units is 63.7 per cent. This is a direct system. The four units are relatively small, and all are constant speed units. They are operated close to their point of test efficiency at all times.

A third plant considerably larger than either of these two just spoken of, pumps into rather large reservoirs and the pumpage rate is practically constant from day to day. This plant is operated on purchased power, and the average operating efficiency for 12 months is 83.6 per cent. Tests on the two units operated, both of them variable speed units, give an average efficiency of 82 per cent. The efficiency of 83.6 per cent is hardly reasonable. The variable in measuring average operating efficiency and test efficiency is the head against which the units operate, which varies considerably. The only conclusion that can be drawn from these figures is that the operating efficiencies of these motor driven pumps, which deliver water into a reservoir at a very nearly constant rate, is very near the best test efficiencies of the units. Of the two units in this plant, one has a capacity of 14 and the other of 21 m.g.d. They, therefore, may operate very near to the designed conditions at all times as the one of the most suitable size may be operated all the time.

These last two cases cited illustrate the desirability, when installing several units at a station, of not getting two or three units of the same capacity. A little care in selecting the capacities of the units will result in being able to operate at full load at all times and with consequent high efficiency. When more than one unit is installed, with a change in load, one pump may be readily shut down and

another started up and the most suitable unit always kept in operation.

With the interconnection of transmission systems, electric power is quite reliable, but some duplication is usually necessary. Judging by the experience we have had in two particular cases, it would seem probable that the duplication need be for use only for a short time. One plant supplied by a transmission line, 7 miles long, from the nearest sub-station, and that sub-station supplied by only one high voltage line, 25 or 30 miles long, has been subject to no extended outages. They have a number of times had power off for 15 minutes to an hour.

Another plant supplied by one transmission line, 1 mile long from the nearest sub-station, which does not supply any other consumers, and the sub-station supplied with power from a single high tension line, 15 to 20 miles long, has suffered from only occasional outages of from 15 to 20 minutes within the last two years. It would seem probable that, in supplying duplication for a plant operated on purchased power, unless the conditions were such as to make interferences likely, an outage of more than two hours would not be likely to occur.

Summarizing:

1. We may say that a pumping station operated from purchased power will on operating cost alone be cheaper than with steam for plants whose load is from 100 to 200 water horse-power and below, the advantages of purchased power being greater as the plant becomes smaller.

2. When fixed charges as well as operating costs are considered, purchased power will probably be the cheapest plant to build and operate where the load does not exceed about 400 water horse-power.

3. For operation of a plant with purchased power, care should be taken to select units which will operate very near their peak efficiencies at all times. It is probable that for a direct system the average operating efficiency of the unit may be about 95 per cent of the guaranteed efficiencies provided suitable equipment is installed.

4. Purchased power with the present interconnection of electric systems is quite dependable and except for unusual conditions outages of more than 2 hours should not be expected.

HIGH MANGANESE EFFLUENTS FROM IDLE FILTERS[1]

By A. C. Janzig[2] and I. A. Montank[2]

Nearly all waters contain manganese in varying concentration, and this element occurs to a greater extent than is generally appreciated. Water works literature cites a number of instances in which the concentration of manganese in raw water is such as to constitute a problem in its removal. Ellms (1) states that in a great many European water supplies the occurrence of manganese is common, and the amounts found range from 0.1 to 6.5 p.p.m. In this country, in 1916, Corson (2) made a complete report on the prevalence of manganese, giving the various concentrations in which this element occurs. Out of 147 waters from wells examined, 60 showed a manganese content ranging from 0.03 to 2.8 p.p.m. From 10 springs analyzed, 6 samples contained no manganese, 3 contained 0.40 and 1 contained 7.8 p.p.m., while 11 out of 16 streams yielded from 0.02 to 9.0 p.p.m. manganese. Monfort (3) makes the statement that manganese is rarely absent from ground and surface waters. He also states that the greatest amount of manganese found by him in Missouri waters is at Excelsior Springs, where 4.5 p.p.m. of manganese occurs. A 1928 report by Lathrop (4) on Water Purification Problems in Ohio shows that the water supply at Barberton contained 1.0 p.p.m. manganese, while in the Ohio River a recent sample from Steubenville had a manganese content of 4.8 p.p.m.

The necessity for removal of manganese from a potable water supply is evident in a consideration of the various complaints which are apt to result when manganese is present in concentrations exceeding the tolerable limits. *Water Works Practice*, 1925 Edition, states that the amount of manganese required to produce complaint is not well established because this metal seldom is found unaccompanied by iron. The best information available is that the sum of these two metallic elements may not exceed 0.30 p.p.m. without complaint.

[1] Presented before the Minnesota Section meeting, June 14, 1929.

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Manganese troubles manifest themselves in the form of staining, incrusting and interference in the o-tolidine test for residual chlorine.

Baylis (5) at Baltimore in 1923 reported a sudden increase in the manganese content of the city water supply, which caused many complaints of stained clothes and white-enameled water fixtures. The increased manganese was detected in a search for the cause of an interference in the o-tolidine test for residual chlorine. Kneeland (6) reports manganese trouble in the form of pipe line deposits and yellow laundry stains from water produced by a filter plant in a western Pennsylvania community. Forsberg (7) in the Iron Range district of Northern Minnesota has pointed out the discrepancies between apparent and true o-tolidine reactions caused by manganese in spring and lake waters. He concludes that waters containing even very small amounts of manganic hydroxides give the same reactions as do those produced with free chlorine. In 1925 at New York City, Hale (8) received numerous complaints of the staining of clothing which were traced to high manganese content from the Croton water supply. Besides the ordinary complaints received, laundries complained of the spotting of clothes by the setting of the bluing. Coincident with the appearance of these complaints, interference with the o-tolidine reaction was found. Hale proved that very small quantities of manganese, less than 0.3 p.p.m., may cause trouble. A recent article by Parks (9) of the Iowa Department of Health states that it is his belief that manganese in well water supplies is responsible for giving false readings of chlorine with the o-tolidine reagent.

A study of the foregoing references will reveal that waters obtained from either underground or surface sources are likely to contain manganese and that this occurrence is not restricted to any particular locality. Also, the presence of this element in a water supply is attendant by such troubles as reported in the literature quoted.

In reviewing the analytical data for the past two and one half years at the Columbia Heights Filtration Plant, we found that the monthly composite samples of the plant effluent yielded manganese, in several instances, in amounts ranging from 25 to 200 per cent greater than that found in the raw water samples. Although these amounts were far below the tolerable limits, the increase was such as to suggest another source of manganese. Since the raw water contained relatively small quantities of the element, it seemed logical, to assume that some stage in the treatment of water was responsible

for the increase of manganese. Because it is well known that manganese is deposited and retained on the sand grains of filters this seemed the most probable origin of its increase.

In this work we are dealing with a source of contamination in the plant effluent brought about by the resolution of the manganese oxides from the sand grains of idle filters. This condition is possible even though a raw water supply may contain only small quantities (less than the tolerable limits) of manganese compounds; because a gradual accumulation of the element takes place in filter beds where it may again be redissolved when conditions become favorable.

EXPERIMENTS AND RESULTS

The Columbia Heights Filtration Plant contains two sets of rapid sand filters. Filters numbered 1 to 16, inclusive, are as a general rule in service a greater part of the time, while the set of filters numbered 17 to 24, inclusive, have been used only in cases of emergency during the past 2 years. The latter filters had been out of service for many months and were utilized as a means of determining the extent to which manganese redissolves from the filter beds while in contact with wash water over a period of time. While remaining idle, the filters 17 to 24, inclusive, were washed periodically, about once every month during the winter months and more frequently during the warmer weather. During the month of May they remained idle, in contact with about 20 inches of wash water covering the surface of the sand. Twenty-five samples of water taken from the surface of these filters (about 1 inch above the sand) had a manganese content greatly exceeding the tolerable limits and in one sample 15.0 p.p.m. manganese were obtained. Four of the filters had been treated with 2 p.p.m. copper sulfate in order to check the growth of algae which had been troublesome in the past. In table 1 the results obtained from these 4 treated filters, are compared with 4 untreated filters. It will be noted that the treated filters gave a lower manganese content than the untreated filters.

An additional matter of interest in this connection was to determine to what extent biological action influenced the dissolved oxygen content and the hydrogen-ion concentration. The water as applied on these filters had dissolved oxygen content of from 7.0 to 8.0 p.p.m. and an initial pH of 6.7. After the 31-day idle period samples of water from 3 filters gave zero dissolved oxygen, while the samples

from the remaining 5 gave values below 1.5 p.p.m. The hydrogen-ion concentration changed to a minimum of pH 7.1 and maximum of pH 7.6.

The next problem was to determine whether or not a filter which had remained idle and then washed would deliver manganese when placed into service. Hourly samples were taken from the effluents

TABLE 1

Manganese in surface samples from treated and untreated idle filters

Results in parts per million

TREATED FILTERS*		UNTREATED FILTERS	
Number of bed	Manganese	Number of bed	Manganese
	p.p.m.		*p.p.m.*
17	1.0	18	4.5
19	3.8	20	15.0
21	1.5	22	3.8
23	1.0	24	6.0

* Treated with 2 p.p.m. copper sulfate.

TABLE 2

*Comparison of manganese in parts per million with false chlorine produced in the sample**

SAMPLE	MANGANESE	FALSE CHLORINE	
		10 minute contact	50 minute contact
	p.p.m.	*p.p.m.*	*p.p.m.*
1	15.0	0.07	0.10
2	6.0	0.04	0.06
3	4.5	0.08	0.12
4	3.8	0.04	0.04
5	3.8	0.04	0.07
6	1.0	0.04	0.07
7	1.0	0.03	0.05
8	0.5	0.01	0.02

* Using o-tolidine made according to *Standard Methods*, 1925 Edition.

of two filters that had been out of service 5 weeks and were analyzed for their manganese content. The results obtained, as indicated in figure 1, show that these filters delivered water with a manganese content far in excess of the amounts delivered by filters in regular service. It will also be seen that the curves represent values greatly exceeding that of the tolerable limits.

In a series of samples an attempt was made to correlate the manganese content with the degree of reaction that takes place when the o-tolidine reagent is used. Table 2 shows the extent to which manganese in parts per million is related to the false chlorine readings in parts per million. Samples 2, 4, and 6 vary considerably in manganese concentration, but all apparently react to the same degree with o-tolidine reagent after a 10-minute contact period. Sample 2 exceeds that of sample 5 in manganese content by more than 1.5 times, yet the same amount of false chlorine is produced by both. In a comparison of sample 1 with sample 8, it is noted that a difference

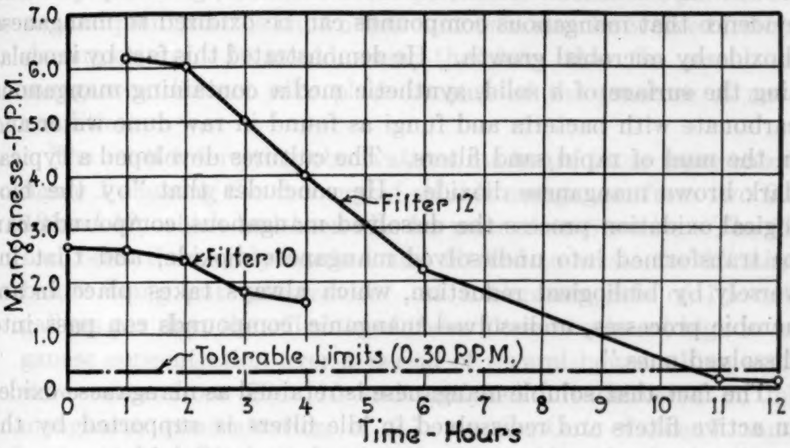

FIG. 1. MANGANESE IN THE EFFLUENTS OF TWO FILTERS, IDLE 38 DAYS AND OPERATED AT A RATE OF 1.5 M.G.D.

of 30 times in the manganese content exists while the difference in the false chlorine obtained amounts to only 7 times. The 50-minute contact period with the o-tolidine reagent gave values from 0.01 to 0.04 p.p.m. higher than that of the 10-minute period. However, one sample failed to show an increase of false chlorine.

DISCUSSION

Early investigators have attempted to explain the deposition and resolution of manganese in filter sands on the basis of physicochemical action rather than by biolysis. Able support of the biological theory in bringing about a change of manganese from the soluble to the insoluble form and vice versa, is presented by the

independent work of Baylis (5) and Kühr (10). Baylis demonstrated by laboratory experiments that the deposited manganese on sand will redissolve. He used samples of sand taken from filter beds which were covered with slime produced by bacterial growth, and submerged them in water for a week or more. The solution obtained from this sand contained about 10 p.p.m. soluble manganese. He repeated this experiment a number of times, and in every case when the sand was covered with slime there was an increase of soluble manganese. He considers that in covering the deposited manganese with slime, the bacteria produce conditions favorable for its being thrown into solution. Kühr, on the other hand, gives experimental evidence that manganous compounds can be oxidized to manganese dioxide by microbial growth. He demonstrated this fact by inoculating the surface of a solid, synthetic media containing manganous carbonate with bacteria and fungi as found in raw dune water and in the mud of rapid sand filters. The cultures developed a typical dark brown manganese dioxide. He concludes that "by the biological oxidation process the dissolved manganous compounds can be transformed into undissolved manganese dioxide, and that inversely by bioliogical reduction, which always takes place in anaerobic processes, undissolved manganic compounds can pass into dissolved ones."

The fact that soluble manganese is retained as manganese oxides in active filters and redissolved in idle filters is supported by the results obtained in the experiments conducted. Soluble manganese found in 25 samples of water taken from the surface of idle filters seems to confirm the biological resolution theory, and the negligible amount or absence of manganese in the effluents of filters in regular service adds evidence to the known fact that retention of manganese compounds as insoluble manganese oxides occurs on sand grains. In table 1 a comparison is made between the amount of soluble manganese obtained from a set of treated and a set of untreated filters. Probably this difference would have been even more marked had the treated filters received frequent and larger doses of copper sulfate. This phase of the subject will require further study in order that more definite and complete information can be secured. A suggestion is also seen for further investigation in the use of other sterilizing agents which would be applicable for filters out of service. If no subsequent operating difficulties arise another means of preventing the resolution of manganese may be found in permitting filters to remain dry during their idle period.

That conditions were favorable for anaerobic decomposition in the water on these idle filters is evident since the dissolved oxygen content in 5 filters was very low, and in 3 of the filters it was zero. Originally the applied water had a dissolved oxygen content of about 7.5 p.p.m. The logical deduction to be drawn here is that the depletion of oxygen was due to aerobic biological activity, since the loss of oxygen can be explained in no other way. Another condition probably brought about by biological action is the change found in the hydrogen-ion concentration from a pH of 6.7 in the applied water to an average of about 7.3 at the end of the 31-day period. It is possible that the end products of anaerobic decomposition increased the pH above the neutral point, as it is known that ammonia may be evolved from such decomposition. It would seem, therefore, that the resolution of manganese did not take place because of the presence of an acid condition.

The most interesting observations made are those represented by figure 1 showing the delivery of soluble manganese from two filters, 10 and 12, which had been idle for more than 5 weeks. The filters had been thoroughly washed and filtered to waste for 15 minutes before being put into service. At a filtration rate of 1.5 million gallons per day, the effluents of these filters continued high in manganese concentration over a period of several hours. Five samples were taken from filter 10 and analyzed. It delivered an initial manganese concentration of 2.7 p.p.m. Out of the 7 samples analyzed from filter 12 the initial sample showed manganese to the extent of 6.2 p.p.m. In the latter filter, a sample analyzed after the second hour showed a slight decrease of manganese, and the subsequent hourly samples showed approximately 1 p.p.m. decline in the manganese content. A normal condition with respect to manganese was not obtained until a period of more than 11 hours had elapsed. The initial yield of manganese for filter 10 is only about one half that of filter 12. Although more samples should have been taken from filter 10, it would seem from the curve plotted and also by interpolations that the period of time necessary for this filter to reach a normal output of manganese would be at least 8 hours.

In addition to the samples from the two filters shown in figure 1, one sample was obtained from filter 9, which had been out of service 42 days. This filter yielded a manganese content of 0.40 p.p.m. after it had been in operation nearly 7 hours. The delivery of a high manganese content does not result from filters which are in continuous

operation, as evidenced by the analysis of the effluents of normal filters. The average manganese content of these filters, during the same period of time, rarely exceeded 0.05 p.p.m., and approximately 50 per cent of the time was zero.

Since the effluents of the idle filters delivered such an excessive amount of soluble manganese, it was desirable to know whether or not the plant effluent would show an increase over the monthly average. The monthly composite samples of the plant effluent for the years 1927 and 1928 gave a maximum manganese content of 0.06 p.p.m., a minimum of 0 and an average of 0.02 p.p.m. Two samples of the plant effluent were taken at about 22 and 29 hours after filters 10 and 12 were put into operation. It was calculated that sufficient time had elapsed to allow for a detention period in the clear water reservoir so that a representative sample could be secured. Analysis of the first sample, taken after 22 hours, showed a manganese content of 0.10 p.p.m. and of the second, at the end of 29 hours, of 0.08 p.p.m. While these figures do not represent amounts that are likely to cause trouble, it can be seen that a potential danger exists when a number of idle filters are put into service at the same time.

The reaction of manganese compounds with the o-tolidine reagent produces the characteristic color that free chlorine produces with the same reagent. In table 2 no direct relationship was found to exist between the amount of manganese in parts per million and the amount obtained in false chlorine readings. Campion (11) at the Barberton plant in Ohio gives experimental evidence to show that false chlorine readings reach their maximum value when the oxidation of manganese has gone to completion. Apparently the degree of oxidation in which the manganese exists is a factor in the production of the yellow color with o-tolidine. This may explain the lack of correlation in the values tabulated in table 2. Forsberg (7) made the interesting observation that "Water containing manganese as manganic hydroxides gives the same reaction with o-tolidine as chlorinated water, irrespective of whether a water, alcohol, sulphuric acid or hydrochloric acid solution of the reagent is used." Aside from the deduction made from table 2, a point of interest is found in the fact that the majority of the false chlorine readings produced by manganese compounds increased with time, while on the other hand it is a well known fact that in the test for free chlorine the converse is true.

From a consideration of the bio-chemistry of the subject the deductions are that the deposition of manganese is caused by a

biological oxidation process; and inversely, the biological reduction induced by anaerobic decomposition converts manganese oxides into the soluble manganous compounds. The layer of manganese oxide deposit formed on the sand grain serves to attract more soluble manganese, which in turn is oxidized by the aerobic microbes to the insoluble form. The process is continued until finally the sand grains are covered with many layers of manganese oxide.

In the case of incrustations formed on the sand grains of filters where alum is used as a coagulant, there exists, in addition to an insoluble manganese oxide and bacterial jell, aluminum hydroxide. The two latter substances may occur in intimate combination with the manganese oxide, or they may occur in alternate layers with the manganese oxide. The writers believe that when anaerobic decomposition has rendered the manganese oxide soluble, the coatings of bacterial jell and aluminum hydroxide probably act in a manner similar to that of a semi-permeable membrane, delaying the rate of diffusion of soluble manganese from the sand grain. It is therefore reasonable to suppose that, when a filter is washed, only the outer soluble manganese compounds are rapidly removed. Following this reasoning it is probable that after the filter is placed in service, the hydrostatic pressure created is sufficient to draw the soluble manganese out from the inner layers of the same grain. This explanation may account for the delivery of a high manganese content over a period of 8 hours or more by idle filters which are again put into service.

SUMMARY

1. Analytical data are presented to show that manganese is redissolved from the sand of idle filters.

2. It is demonstrated that the effluents of idle filters will deliver a high concentration of soluble manganese, and that this condition may continue for a number of hours.

3. No direct relationship is found between the amount of manganese present in a water and the amount of false residual chlorine produced with o-tolidine reagent.

4. The information obtained thus far indicates that biological action is an important factor in the process of redissolving manganese.

5. A suggestion for the prevention of the resolution of manganese in idle filters may possibly be found in the proper use of copper sulfate.

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DECREASE FIRES THROUGH BETTER FIRE PROTECTION[1]

By Percy Bugbee[2]

One of the main difficulties encountered when an individual or group of individuals set out to attack the fire waste in a community is the diversity of the problem. Fire protection or fire prevention cannot be easily defined. There are many ramifications which often lead to consideration of problems not really pertinent to the subject involved. It seems desirable, therefore, to discuss in this paper some concrete means of securing better fire protection to the end that the fire losses in any community may be decreased.

In a survey which the National Fire Protection Association has been making in one of the large cities of the country, a careful study has been made of the national fire loss figures for the past twenty years. If the fluctuating value of the dollar is taken into consideration and the fire loss curve is deflated accordingly we find that instead of a heavy increase in fire losses year by year, as shown by actual fire loss figures, there is really a slight decline. In the campaign against fire waste we have been a little more than holding our own when increased property values are taken into consideration. Steady improvements in water supplies for fire protection and in fire departments undoubtedly have had a substantial effect upon keeping the level of losses from increasing rapidly. Progress in the art of building construction and the gradual replacement of old buildings with modern fire resistive structures also have their effect on fire records, in spite of the fact that the building codes of a great many of our cities and towns are still entirely inadequate.

It is only comparatively recently that we have come to realize that there is a good deal more to municipal fire prevention than simply providing the necessary fire fighting facilities to take care of fires when they occur. In many of the cities visited in the interest of fire prevention work the fire record kept by the fire department is

[1] Presented before the Indiana Section meeting, February 26, 1929.

[2] Assistant Managing Director, National Fire Protection Association, Boston, Mass.

extremely meager. In other cities accurate and complete fire records are kept but no attempt is made to analyze the figures obtained. It is reasonable to suppose that no problem involving waste of resources or life can be intelligently attacked or solved unless we know the exact conditions responsible. Yet there are many cities that dissipate what energy they have to give on fire loss reduction in meaningless channels when the record is considered. The keeping of an adequate fire record should be a cardinal principle in any municipal fire prevention campaign. The fire department should have an accurate record of fires with data as to the cause, the amount of loss, the structural factors involved, and the character of occupancy. Data from good fire records offer the finest argument for securing improvements. Suppose, for example, that the fire record shows a predominance of rubbish fire in business buildings. Such a condition should clearly indicate the need of establishing adequate inspection work in the fire department. If the fire record shows a large number of fires due to sparks on wooden shingle roofs, an ordinance prohibiting the use of wooden shingles for roof covering should be adopted. If the fire record shows numerous fires in oil burning equipments, the adoption of an ordinance regulating the installation of oil burners should be secured. If the fire record indicates that there are many fires in mercantile buildings, a campaign to secure the installation of automatic sprinklers in those buildings should be undertaken. If there are heavy losses on the contents of mercantile buildings, provision for salvage work in the fire department is indicated.

A factor of great importance in municipal fire prevention work which has been neglected until recent years, is the matter of fire department inspection. In every city and town down to the smallest community some provision for systematic inspection of buildings should be made. There is no other phase of fire protection work that will so quickly reduce the number of fires in any city as inspection work. In addition to disclosing common fire hazards, inspection work has the double advantage of familiarizing the firemen with buildings in which they may have to fight a fire.

We have found in our national campaign to reduce fire losses that to be successful individual cities must be stimulated and aroused to the importance of decreasing their fire waste. It is correspondingly true that a fire prevention campaign in any city must rest upon the correction of conditions in individual properties. The large industry of today that does not maintain adequate local fire protection for

its own property is an exception. This is not true, however, of the properties in the congested, high value mercantile districts of our cities. A great deal needs to be done in educating the owners of relatively small tenant manufacturing or mercantile buildings to the value of automatic sprinklers, fire shutters, protection of vertical openings and other well recognized means of preventing or controlling the spread of fire. Some effective work along these lines is now being carried on in Indianapolis.

There are, of course, in every community individuals who cannot be reached by persuasion and who remain indifferent to the fire waste. The principle of personal liability for fire loss is entirely sound, and will inevitably be accepted sooner or later in this country. If a property owner fails to heed the recommendations of the fire authorities and through his own carelessness or negligence causes a fire, he should be liable to the city for their expense in extinguishing his fire, and to his neighbors for any damage he may cause them.

To take care of the criminal or incendiary prompt and thorough investigation of suspicious fires is necessary. This can best be done by creating an arson squad, consisting of a policeman or detective and a fireman, whose responsibility it is to apprehend the incendiary. Indiana has the model arson law so that there should be no impediment to prompt conviction.

I have assumed that you are interested in fire prevention work in your own community. If you are not, you should be. If there is no fire prevention committee in your community, help to create one. If there is a committee, help to keep it away from generalities and to concentrate on those things which will correct the more important hazards. There has been too much conversation and misdirected effort in fire prevention work. If our cities would adopt a common sense, practical viewpoint of their fire protection problems, decreased fire losses would inevitably follow.

APPRAISAL OF WATER WORKS PROPERTIES[1]

By H. F. Wiedeman[2]

The appraisal of water works and other public utilities properties is a controversial subject upon which volumes have been written. Although it is not possible to discuss it adequately in a brief paper, the intention is to point out, in a general way, the factors which must be considered in the making of an appraisal, to discuss some of the difficulties which confront the appraiser, who is honestly attempting to make a fair estimate of the value of such a property, and to attempt to show that a need exists in many of our municipally operated water plants in the southeast today, for more accurate information as to the value of their properties, and the amount of the fixed charges which must be obtained from revenue, if the property is to be self-sustaining.

There are three methods which may be used to determine the value of a water works, or other public utility property, (1) the historical cost, (2) the original cost based upon present inventory, and (3) the reproduction cost.

The history of public utility appraisals is replete with controversies among the advocates of the various methods. Many arguments may be advanced for the use of any of these methods, and it is not the purpose of this paper to discuss their relative merits. The decisions of the Courts, while they have often been contradictory, generally indicate that, while the original cost may be helpful in determining value, the reproduction cost is the best evidence of value. It is needless to say, however, that irrespective of the method used, the appraisal should be fundamentally a matter of fair dealing, and should be made with honest intent, and with a sensible method of procedure.

Appraisal work can never be an exact science. It is almost always necessary to resort to some approximations, but two experienced appraisers, working separately, but honestly and impartially, should obtain results which are reasonably correct.

[1] Presented before the Kentucky-Tennessee Section meeting, January 24, 1929.

[2] Consulting Engineer, Atlanta, Ga.

INTANGIBLE AND TANGIBLE VALUES

No matter which method is used, the items of cost will consist of intangible and tangible values. The intangible values are costs, either estimated or actually incurred, to establish the business and include the "overhead" cost incidental to construction, and going concern value. The overhead costs may usually be readily determined with a fair degree of accuracy, because experience in the promotion and construction of utilities, has furnished us with sufficient authoritative data. The going concern value, however, is difficult and often impossible to determine. Engineers have attempted to compute this value based on various hypotheses with but little success. One authority in discussing this item, says "As the character and amount of these costs never repeat themselves exactly, the attempt to derive an accurate mathematical result from a fundamentally variable and unpredictable amount is futile."

Courts and public service commissions have set this value in a number of cases, and the general average seems to be about 10 per cent of the value of the physical property. While it is possible to demonstrate that this item of value does exist, it would seem that its amount is a matter of sound judgment rather than of practical calculation.

The tangible values include the actual equipment with all costs of installation, and are items which may be definitely inventoried.

The determination of the tangible costs of a property recently constructed, where complete records are available, is a comparatively simple matter.

When the construction has been carried on piecemeal, however, over a long period of years, and records which would establish subsurface construction and conditions, and other necessary historical data, are either fragmentary or non-existent, the problem becomes difficult and laborious. Each case will present a new or different problem. There are many differences as to detail in the methods used, and there are many items of uncertainty.

Under a literal and technical interpretation reproduction cost may be construed to mean that allowance should be made for the cost of tearing up and replacing pavements, which did not exist at the time the plant was constructed, and for difficulties which would be encountered, due to the present congested conditions of streets in the business sections of our cities, and the multiplicity of underground structures, which would make pipe laying difficult. Other

assumptions might be made which would give the utility credit for materials, and labor which were never used, or expended. While it may be said that such charges are proper, if we are to be consistent in the use of this method, the courts have generally refused to make such allowances.

Engineers now generally understand reproduction cost, as meaning the cost at present prices of material, labor and equipment, and with present methods of doing what was done when the property was created.

Another debatable question is the price to be used for materials, labor or equipment. In a number of cases, the spot cost or the cost as of a certain date, has been used, but it has been the practice of many appraisers to use a price level for a five or ten year period preceding the time of the valuation, or better still, to use prices which the general trend indicates will be reasonably correct for the immediate future. The use of spot prices, when the price levels are changing rapidly, cannot produce satisfactory results, because by the time the appraisal is completed, and ready for submission, it is incorrect.

DEPRECIATION

Depreciation is the decrease in the value of any material or piece of equipment, due to use or change in condition of use.

There are two kinds of depreciation, physical and functional.

The physical depreciation is the reduction in value due to wear, corrosion or whatever phenomena cause it to deteriorate gradually so that it can not perform its function.

Functional depreciation may be due to obsolescence or inadequacy. If due to obsolescence, it is caused by improvements and inventions in equipment which render the equipment in use inefficient, while, if due to inadequacy, it is caused by changed conditions, which increase demands upon plant units and render them too small to perform the required service.

The whole subject of depreciation is a most difficult one, and one upon which much difference of opinion exists.

It has been customary with many appraisers to base the physical depreciation of material and equipment entirely upon the time the items have been in service under the theory that every article has a definitely fixed life. Further differentiation has been made by the use of the sinking fund method which assumes that the depreciation in the earlier years of the life of an article is less than it is in the latter

years of its life. Tables on both the straight line method and the sinking fund method have been built up, using for the life of various materials and equipment, an average figure based presumably on experience. The use of this method does not take into consideration the conditions of service to which the articles have been subjected.

Several years ago, a water plant in Florida was considering the installation of additional service connections and the question arose as to whether the use of galvanized steel pipe should be continued, or whether it would be more economical to install a more durable and more expensive material. Most of the services were comparatively long lines, laid through areas which would, in the future, be expensive lawns and shrubbery. Therefore, long life was a desirable factor. A careful examination of existing services was made. Sections were removed from a number of points in the system, and in no case, was there any appreciable deterioration. In fact, when some of the samples which had been in the ground from 4 to 7 years, were examined, the galvanizing was practically intact. On the other hand, the writer has examined services of this type which have been in service for the same period, which were in such a condition that replacement in a few more years was clearly indicated as necessary.

The character of the water used, the soil and other local conditions affect the durability of distribution system materials and equipment so greatly, that a careful examination is necessary in each case before it is possible even to approximate the depreciation which has taken place.

The above remarks apply equally as well to structures and other water works equipment.

It is not intended to infer that the examination and inspection of all water works equipment will enable the appraiser to arrive at the precise amount of depreciation which has taken place. It is manifestly impossible for even the most experienced water works man to examine, say, a piece of pumping equipment which has been well maintained and say accurately what physical depreciation has taken place. Such an examination, however, will furnish him data upon which to base his judgment, which should produce a much more accurate result than the assignment of an arbitrary amount, based upon experience under operating conditions, which may have been entirely different.

The matter of functional depreciation does not always receive the consideration it should have. It is true that the proper charges

are usually made when the equipment is replaced, due to its inability to carry the load or because of its gross inefficiency, but rarely is the necessity of such a change anticipated sufficiently in advance so that proper provisions are made for it. A thorough study of the operating conditions and the growth of the various sections of the city, which the plant is serving, will aid materially in anticipating these changes and providing the necessary depreciation allowance therefore.

MUNICIPALLY OWNED PLANTS

Many of our municipally owned water plants are functioning as departments of their city government. Fire protection and free water are furnished the municipality, and the cost of service is borne by tax payers and consumers in a more or less indefinite ratio.

Some of the largest municipalities in the Southeast are operating under this plan, with evidently satisfactory results, but a number of our municipalities are operating their water works plants as separate utilities, which must be self-sustaining.

This method of operation is increasing and will continue to increase as the recognition of the basic principle of the equitable distribution of the financial burden of the cost of service becomes more general.

Any utility, in order to be self-sustaining, must earn its operating expense, the interest on its debt and an annual allowance for depreciation. It should also earn a surplus to provide for contingencies or emergencies.

The operating expense is usually the subject of close scrutiny and is generally know, but, in most cases, where the plant has been constructed piecemeal over a long period of time, the book value carried is far from correct.

In one plant recently appraised, the book value was less than 50 per cent of the fair value of the plant. In this case, while the percentage of depreciation was reasonably correct, the annual amount allowed was, of course, inadequate and the plant which was assumed to be showing a small profit, was really operating at a loss.

It is interesting to observe the operation of municipally owned combined light and water plants. In practically all the cases which have come under the writer's observation in this territory, the operation of the electrical utility shows a generous profit, while the water plant invariably shows a loss or a very slender margin of profit. The

public has evidently been educated to pay what it is worth for electrical service, but the old idea that water is and should be free, or practically so, still persists in many places.

There are financial complications in the operation of a municipal plant, which do not exist in the privately owned plant. In many states there is a legal limit of debt which the municipality cannot exceed. Consequently bonds can not be refunded, as in a private enterprize, but must be retired either by a sinking fund, or by the payment of serial bonds, as they become due, in order that extensions in all departments may be financed. In Georgia, for instance, the constitutional debt limitation for all purposes is 7 per cent of the assessed valuation. It is difficult to meet the needs of the modern growing city and keep within this limitation.

The creation of a sinking fund, or the retirement of serial bonds, is, of course, capital investment, and theoretically these payments should not be obtained from revenue. This is not always practical or advisable, however, and quite frequently it becomes necessary to adjust rates to the point, where the revenue will not only provide for the cost of service, but will also retire the debt. Local conditions usually determine the course which must be adopted.

It is just as necessary for a municipally owned, as it is for the privately owned, utility to have accurate information as to the cost of service, if there is to be equity between tax payers and consumers and if a healthy plant condition is to be maintained.

DISCUSSION

A. F. Porzelius:[3] Fire protection is often considered as a free service in a municipally owned plant, which is not just to the rate payers who must pay for such service in the water rates, if the plant is to be self-sustaining. For this reason, even a municipally owned plant should charge the city a certain amount for fire protection. In our own case, where the city does pay us a fire service charge, we pay much more in taxes than they pay us for fire protection.

Beekman C. Little:[4] I gave up my actual operation in water works some time ago. I am interested in the statements of privately owned plants. They know more about it than municipally owned

[3] Superintendent, City Water Company, Chattanooga, Tenn.

[4] Secretary, The American Water Works Association, New York, N. Y.

plants because they keep better records. That is a very bad thing for a municipal owner to admit, although it is true. It is adjusting itself more and more and they are gradually improving.

In general, municipal plants are charging for fire protection and making a higher rate for water. In some states the law now provides that municipal as well as private plants should keep complete financial records of their operations.

DEAERATION OF WATER IN RELATION TO CHARACTER OF WATER SUPPLY[1]

By J. R. McDermet[2]

The removal of dissolved gases from water for the prevention of corrosion has been practised in the power plant industry for approximately eight years. During this period of time it has gradually been extended into the protection of hot water piping supplying large buildings. Accordingly, its significance, from the standpoint of the character of water supplied by the utility, is of importance to the engineers and chemists of the American Water Works Association.

The methods of protection by the removal of dissolved gases have developed under two names. The first of these is "deactivation," which amounts to the removal of dissolved oxygen by causing the water to lose its rusting properties by attack upon scrap metal in a process of treatment. The other term, "deaeration," implies the removal of all dissolved atmospheric gases in the water by a vapor phase equilibrium process, in which water is intimately contacted with an atmosphere of extremely low atmospheric gas content.

Deactivation is apparently a simple matter. From the standpoint of the chemistry of water it is not quite so simple, as we shall see later. Because of its apparent simplicity, it has found application where small quantities of water are to be treated. Because of the slow character of the corroding reaction between water and scrap metal, the size of the apparatus is prohibitive for large quantities of water.

Deaeration, however, is able to handle, in feasible size of apparatus, almost any quantity of water which is used in a heated condition. It is also applicable to cold water, but the uses of unheated water are so varied and so extravagant that it has not been commercially practical to treat cold water supplies.

Dissolved oxygen, and, to some extent, carbon dioxide, are ordinarily the only gases toward which attention is directed in the control of corrosion by these methods. Deaeration, of course,

[1] Presented before the Session of the Committee on Boiler Feed Water Studies, the Toronto Convention, June 25, 1929.

[2] Research Engineer, Elliott Company, Jeanette, Pa.

removes all gases, except carbon dioxide, almost completely. Deactivation removes only the dissolved oxygen. Heated water is far more corrosive than cold water, and as a result it has been found of maximum benefit, in the case of heated water supplies, to remove all of the dissolved oxygen and as much of the carbon dioxide as is possible. On cold water supplies, a removal to reduce the dissolved oxygen to less than 0.5 cc. per liter appears to be adequate in a practical sense.

The control of corrosion by the removal of dissolved gases is obviously inter-related with the character of the water, and it is proposed to limit this paper strictly to the aspects which relate to water quality.

By far, the largest use of deaeration has been in the preparation of boiler feed water in steam power plants. In the majority of large power plants the boiler feed supply is condensed steam from evaporators or surface condensers; in other words, virtually commercial distilled water. In the smaller plants, the local water supply furnishes the feed water. Condensed steam used in central power stations usually has a hydrogen ion concentration varying only a few points from neutrality, pH 7.0. While distilled water is commonly regarded as a corrosive form of water, it has been easy to completely eliminate corrosion at any temperature encountered in steam power plant service below 550°F. Above this temperature evidences of corrosion occur which are now thought to be occasioned by the decomposition of water itself.

Upon waters obtained from natural sources and, therefore, to some extent contaminated, the calcium content is a logical means of grouping corrosion phenomena. It has been known for a considerable time that lime bearing waters are less corrosive than waters free from lime. Naturally, this fact correlates closely with the pH values, since lime bearing waters are usually alkaline on the pH scale. Part of the immunity of lime bearing waters is therefore measured by the increased pH; part is also undoubtedly involved in the ability of lime bearing waters to deposit protective films when heated.

Upon lime bearing waters having a pH greater than 7.5, the reduction of dissolved oxygen to the limits given previously is likewise a complete control of corrosion. Waters of this character having a pH lower than 7.5 are sufficiently abnormal to make a further generalization difficult; but, in the absence of identified acidity, protec-

tion is usually afforded within pH limits specified for non-lime bearing waters below.

There are certain areas in both the United States and Canada, well defined geographically, where the lime content of surface waters is substantially zero. Apparently, this phenomenon has originated not in the character of the strata, but in the presence of vegetable matter which has precipitated the lime. These waters are uniformly faintly acid. With such waters it has been found possible to afford useful but not complete corrosion protection if the hydrogen ion concentration does not fall below a Sorensen number of 6.0. This value of pH is considerably above the value at which hydrogen overvoltage phenomena begin to affect corrosion as values are commonly accepted, and therefore this observation is difficult to reconcile with the range of hydrogen ion concentration in which dissolved oxygen is thought to be the regulatory function governing corrosion. It is possible, however, that the presence of obscure organic acids and the impurities of commercial metals affect these limits, and that the value of pH 6.0, if all the facts were available, would be strictly consistent.

Standard commercial deaeration apparatus normally can be guaranteed and expected to remove all of the free carbon dioxide, and in the case of lime waters, to remove approximately 40 per cent of the bicarbonate hardness, if it exists around 50 parts per million. With increasing calcium bicarbonate content, more removal of course is effected, but the percentage values decrease. Carbon dioxide-bicarbonate-carbonate equilibrium for calcium is a shifting condition, which makes the interpretation of results exceedingly difficult in view of the existing data which are determined for only a few temperatures. As a result, while the breaking down of calcium bicarbonate in connection with deaeration can be counted as a most useful effect, it is impossible to specify an amount in terms of commercial guarantees. If an attempt is made to do so at present, either extensive research is required or troublesome controversies will arise.

High calcium waters are softened by at least two methods which are widely used, viz., lime-soda and zeolite.

It is possible to deaerate a lime-soda water softened either by hot or cold process methods with complete success in corrosion prevention. The reason for this can be ascribed to at least three factors: the presence of residual lime, in that the softening reaction has not been pushed to equilibrium; the addition of alkali to force equilibrium

further, and to produce thereby an incidental additional alkalinity; and, finally, by the removal of carbon dioxide free and half combined.

Waters treated by the zeolite process offer difficulties in which carbon dioxide apparently plays a rôle as important as dissolved oxygen. Relationships between carbon dioxide-bicarbonate-carbonate existing as sodium now apply, and it appears that there is less knowledge concerning these ratios; that there is more tendency for the equilibrium to shift in the direction of carbon dioxide with increasing temperatures, and the carbonate portion is itself less stable. As a result, the treatment of these waters is not established with the satisfaction characteristic of other waters. It is also apparently true, however, that the zeolite process of softening is applied to waters more difficult to handle properly from the standpoint of corrosion prevention than the lime-soda treatment. In other words, if one encounters a particularly troublesome bicarbonate water supplied to a softener, the softener is almost invariably of a zeolite character. Doubtless this is due to the necessity on the part of the user of securing a softer water supply so that advantages and disadvantages of the use of zeolite more or less counterbalance.

It is characteristic of zeolized water, when heated, to reveal a very narrow zone of attack from the standpoint of pipe networks. In other words, in the heating process, corrosion develops, which is apparently very active and exhausts itself from its very virulence within short distances measured in terms of path of water flow. With such corrosion phenomena, deaeration in combination with a pH not less than 9.5 after deaeration will provide immunity.

In some rare instances, the injudicious use of acid coagulants preliminary to filtration has upset the natural pH value of the water to the extent that deaeration has not prevented corrosion. Organic matter, sediment, etc., naturally occurring in a water or arising from filtration processes, rarely, if ever, cause any disturbance in control.

Deactivation, as a previous explanation indicated, is a direct rusting process in which scrap iron, usually in the form of sheets, is confined in a tank for exhausting the dissolved oxygen. With waters which do not precipitate either lime or silica, there is ordinarily no difficulty in the rusting process and it is possible, irrespective of the chemical character, to deliver non-corrosive water. It is a difficult job, indeed, sometimes, to make the water palatable or colorless. The difficulty is in the precipitation of the iron rust compounds, which may be variously regarded as a combination of ferrous and

ferric oxides, carbonates or hydroxides. These iron compounds are most frequently colloidal upon formation, and become successively gelatinous and granular. The colloidal or gelatinous forms are practically inseparable since the latter clog filtration apparatus rapidly. The granular forms can be filtered or separated by gravity with perfect satisfaction. Ordinarily, settling is the simplest and most useful process, and, hence, is used in commercial apparatus to the exclusion of filtration.

The character of the water regulates the rate at which the iron compounds will coagulate and settle out, and below a hydrogen ion concentration of approximately 9.3 the process of sedimentation becomes long and expensive. It has been necessary, therefore, to artificially control hydrogen ion concentration. For this purpose there has been developed a coagulant which consists of magnesium carbonate calcined and partially sintered to regulate the solubility on the basis of the magnesium content. The purpose of the magnesium carbonate and its treatment is to secure a material slightly soluble in water and whose solubility will be approximately proportional to the requirements of the water.

Mention was made of the very small quantities of water which deactivation was competent to handle. These small quantities and intermittent flows, of course, made the development of a proportioning apparatus for feeding an alkali almost impossible, in view of the extremely small quantities and variable rates of flow involved in the actual apparatus. The method of adding alkali and increasing the hydrogen ion concentration by regulating the solubility of the magnesium coagulant has solved this problem effectively and with the greatest of simplicity. Unfortunately, while it has many other advantages, it is not an exact method of regulating alkalinity of water and, hence, is subject to the character of the water.

To put the matter in terms of figures, it seems impractical to have any coagulation of iron hydroxides below 8.8 pH. A pH of 9.3 is satisfactory, and there is no merit above 10.5. It is rarely true that the solubility is regulated to reach the upper limit of alkalinity. It is observable that the alkali additions to raise the pH are made in a relatively insoluble, chemically inactive reagent and in exceedingly minute quantities.

The deactivating apparatus, in the absence of effective coagulation, delivers water having both ferric and ferrous compounds in solution, and in the presence of some carbon dioxide or very high oxygen an

objectionable coloration from iron compounds is formed. In the case of high initial corroding power of the water, the iron compounds may, in addition, communicate a characteristic odor to the water as well as a color, and the odor makes a most unpalatable product. In addition, it is difficult to disassociate it from flavor.

Obviously, with an inexact and what one might call empirical method of hydrogen ion control with the magnesium coagulant, the initial character of the water is very pertinent. The commercial apparatus on the market is ordinarily adapted to receive water with a hydrogen ion concentration of 7.5 or greater. If a pH value is received below this figure, it is necessary to make compensation, which is accomplished in most cases by increasing the time of contact between the water and the magnesium coagulant. With low pH numbers the time of treatment becomes objectionable and impractical. In addition, the use of chemical coagulants of an acid character preliminary to sand filtration frequently upset the balance. A process, therefore, superficially simple for removing the rusting powers of water really becomes involved in a considerable amount of chemistry.

You have noticed in the course of this paper the frequent use of pH numbers. It is the writer's impression from such experience as has been had within the range of natural waters, that the hydrogen ion concentration is the most significant measurement of corrosion properties which can be made on a water. It is, of course, not all the story, and frequently other determinations are necessary, but it is always one quantity requisite for corrosion comparisons.

WATER WASTE[1]

By C. P. Gross[2]

In April, 1928, the Water Works and Lighting Commission of the city of Wisconsin Rapids entered into a contract with the Pitometer Company, engineers of Chicago, to make a pitometer water waste survey of the water works system of the city of Wisconsin Rapids for the purpose of determining the following:

1. The efficiency of the pumps capacity.
2. A test of the large water meters at the pumping station.
3. A twenty-four-hour measurement, giving the total consumption of the city.
4. A division of the city into two districts and a twenty-four-hour measurement made of the flow of water into each district.
5. A subdivision of each district into sections of the smallest number of blocks possible in order to determine the distribution of the night rate of flow in each district.
6. Investigation of all high rates of leakage.
7. Investigation for closed valves.
8. Test of all meter services 4 inches in diameter and larger.
9. A check of all large water consumers for the purpose of determining the unauthorized use of unmetered water through fire lines or otherwise.
10. The preparation of a map showing the district boundaries and gaging points and other charts showing the variation of flow into each district.

From the foregoing it can be seen that a water waste survey includes more than the name it implies. Taking the survey as a whole the results were fairly gratifying. We found that the pumps were discharging nearly up to their rated capacity, that there were no appreciable leaks in the water mains, that there were no valves closed and also no concealed valves. We found several cases of consumption of water which were not recording on the meter and also checked up on a number of unmetered services where we found that

[1] Presented before the Wisconsin Section meeting, October 12, 1928.

[2] City Engineer, Wisconsin Rapids, Wis.

the water consumption was considerably larger than we had estimated.

The first figures which we obtained during the course of the work were the figures which showed the capacity delivered by the centrifugal pump. The three centrifugal pumps at the stations in Wisconsin Rapids each have a capacity of 750 gallons per minute. The pitometer test showed that one of these pumps was delivering 736 gallons per minute or an under capacity of 2 per cent. We found that another 750 gallon a minute capacity pump was delivering 740 gallons per minute or about 2 per cent under capacity, and we found that the third centrifugal pump which was rated at 750 gallons a minute was delivering 727 gallons per minute or 3 per cent under capacity. These amounts are not large and we feel that the pumps are delivering up to the amount which could be expected after having been in service for such a length of time.

Two water meters are used in metering the water delivered from the two pumping stations. One is a 6-inch Hersey Torrent meter which was found to be within one per cent of correct registration. The other, an 8-inch Hersey Torrent meter was found to be 11 per cent slow.

TOTAL CONSUMPTION

The next step in the survey was to obtain the total consumption of the system over a period of 24 hours. The two pumping stations are located in entirely different sections of the city and the stand pipe is located about in the center of distribution.

In order to obtain the exact consumption and not have it affected by the quantity of water in the stand pipe, the pitometer was set up near the outlet of the Oak Street pumping Station on an 8-inch main just north of what is known as Oak Street. The 6-inch line leading west on Oak Street was closed and the valve leading to the stand pipe and the third street pumping station were also closed, so that the entire supply of the city was delivered from the Oak Street pumping station through the one main which extends in the north and south direction. During the time of this measurement the centrifugal pump had to run constantly. We found that the total consumption for the day was 584,000 gallons. The minimum night rate was 332,000 gallons per day. The maximum draft for any one hour was between 11:00 A.M., and 12 noon, the rate of which was 961,000 g.p.d.

DISTRICT MEASUREMENT

The next step in the work of making the survey was dividing the city into two parts, district one and district two. District one included that portion of the city lying west of the Wisconsin River. The water mains are carried from the east side of the river to the west side across a concrete bridge. On account of the scarcity of vertical space in this bridge three 6-inch water mains were used instead of one large main. A gaging point was established on the middle 6-inch main inside of a manhole at the west end of this bridge. By closing two 6-inch valves on the other two lines leading across the bridge all the water entering this district passed through the middle 6-inch main and was measured by means of a pitometer installed at the gaging point. The result showed that 65 per cent of the consumption of water took place on the west side of the river and 45 per cent on the east side.

District two included the portion of the city east of the Wisconsin River. The water entering it was measured by means of two gaging points. One point was established on the middle 6-inch main in the manhole at the west end of the Grand Avenue bridge. The 6-inch valves on the other two lines across the bridge were closed. The other gaging point was established on an 8-inch line at the Oak Street pumping station just north of Oak Street. The 6-inch valve leading west on Oak Street was closed. The valve on the line leading into the stand pipe was also closed and the third street pump was shut down for 24-hours. Then all of the water entering the distribution system passing through gaging points number two and all of the water in district one passed through gage number one. Subtracting the measurements at the gaging point number one from that at gaging point number two gave the consumption of district two.

After having subdivided the city into two sections and determining the amount of flow into each section, the two large sections were divided into many small divisions and tests made for the flow of water into each one of these small divisions. During the course of the entire survey observations were made on 98 sections.

The observations for leakage and waste of water on the east side were taken on a water main located on Fifth Street between Baker and Oak Street, while the observations on the west side or district one, were taken on a 6-inch main just north of Grand Avenue on Tenth Avenue.

VALVES

The observations were taken in the following manner: The pitometer tube with the recording instruments were set up in a shelter house over the observation point at Tenth Avenue and Grand Avenue. Valves were closed off in various locations on the west side of the river so that all water feeding to the north of Grand Avenue on the east side of the river had to pass through the 6-inch main where the pitometer tube was set. The next step was to close off enough valves so as to confine the pressure or live water main to a very small area. A hydrant was also opened so as to indicate whether or not there were any valves leaking. As soon as the observers made sure that the valve was tight and that no water was getting out of the area to be tested the hydrant was closed and a valve opened allowing the water to pass into the section on which observation was to be made. If the flow of water was large or if any appreciable amount of water was flowing into that section the record was made by the pitometer tube and recording instruments. The greater the amount of water flowing, the greater the deflection of the instrument. As soon as the flow or leakage in any one section could be determined water was allowed to enter another section after having closed off the valves to be sure and after first making sure that there was no leakage through these valves and the operation. In this way one small section after another could be tested for flow of water from a single gaging station or location on a water main. All of this work had to be done at night, when the consumption or flow of water was very small, because, if the flow was large, it became necessary to determine where the water was going.

If all of the water which was passing through the pitometer tube could not be accounted for by meter consumption, the assumption was that the difference was made up in leaks.

As soon as the section north of Grand Avenue was completed valves were closed so as to reverse the direction of flow and in this way all of the water which fed south of Grand Avenue passed through the same gaging station only in the opposite direction and by adding one section after another the south side of Grand Avenue was completed.

The same method was followed on the east side of the river, all from one gaging station.

The average daily pumping at Wisconsin Rapids is between five and six hundred thousand gallons in 24-hours.

One of the principal things which prompted the water department to have the water waste survey made was the fact that between 45 and 50 per cent of the water recorded at the pumping station was unaccounted for, either in losses due to leakage or in fire hydrants, services, drinking fountains or in other unmetered public services. The reason for the survey was to determine whether or not the unaccounted for water was caused by leakage or by unmetered services. The following conclusions were arrived at.

First, the water mains of the city are practically free from leaks. Second, 86,500 gallons per day were wasted in service, blow off, valve and hydrant leaks and waste in school houses. In other words, 17 per cent of all water pumped was wasted. Third, several water services on municipal lines were unmetered and a large quantity of water was used on these services. Fourth, the direction of opening of every valve in the city was determined and also the fact was proven that there were no valves closed on our system. Fifth, a cross connecting water main that was unknown up to the time of the survey was discovered.

Unless the report and recommendation made on a survey of this kind are followed up the report is of very little value. Since the time that the survey was made all these service leaks have been stopped and the hydrant leaks practically eliminated. A systematic inspection of water meters has been instituted by the meter department and it is hoped with this method of following meter inspection and testing that no meter will be in service more than two years without having been removed and tested. We feel that part of the unaccounted for water is due to under-registration of water meters. Of 140 meters removed, 38 were found defective. Two of these meters were completely stopped and the balance were from 2 to 20 per cent slow. By calculation we find that the loss or under-registration of the 36 meters would be equivalent to an under-registration of 13 per cent of all the water pumped. This is an item in water works operation which is too easily overlooked by many water works superintendents. The 13 per cent loss is a direct deduction of the net earnings of the water works department. The overhead and pumping expenses are identically the same whether the meters are recording or not. If the meters are kept up to proper registration the additional 13 per cent will be that much more added to the net earnings of the plant.

Many water works superintendents, especially in the small plants

the size of Wisconsin Rapids, are very much surprised on making a check up of the unaccounted for water to find the large amount of water pumped which is not recorded on the water meter. I do not believe that the conditions at Wisconsin Rapids are much different from those in any other cities of the same size.

Since stopping the service leaks we have been able to reduce our pumping about an hour a day. With the improved conditions of the water meters, the net profit of the water department cannot help but be larger.

DESIGN AND CONSTRUCTION OF A COVERED CONCRETE RESERVOIR[1]

By C. A. McClain[2]

Eugene, Oregon, with a population of about 22,000 gets its water from the McKenzie River, a stream with a minimum flow of 1500 second feet and a drainage area of about 1000 square miles above the water supply intake. It has its source high in the Cascade mountains near the base of the snow clad Three Sisters.

The water is conveyed to the city through a 30-inch steel conduit seven miles long and is delivered to the filtration plant by gravity. The water is soft and of good quality and although it is Coli negative a fairly large percentage of the time, it can not be used with safety without chlorination. During storm periods, amounting to a total of 10 to 15 days each winter, the water is of such high turbidity as to require treatment by coagulation and rapid sand filtration. Throughout the remainder of the year no coagulant is used and the water passes through the filters which act only as strainers for the removal of floating and suspended matter. The resulting effluent is of excellent quality and is under the control of a bacteriologist at the University of Oregon.

The reservoir which is the subject of this paper was constructed in 1926 on the site of an older and much smaller one which was built in 1887 and had been in continuous use from that time until its destruction in clearing the ground for the erection of the new one.

Its location is on an elevation known as Skinner's Butte, named for Eugene Skinner, the first white settler on the ground now occupied by the City of Eugene and after whom the city also is named.

This Butte was owned by the local water company from whom the city purchased the water system in 1908 and the title to this property, about 60 acres, at the end of the main street and about one-half mile from the center of the business district was acquired by the city at that time. A few years later by a vote of the people it was taken

[1] Presented before the Pacific Northwest Section meeting, November 16, 1928.

[2] General Superintendent and Secretary, Water Board, Eugene, Ore.

over as a park and placed under the control of the Park Commission, granting only to the Water Commission the right to maintain its reservoir thereon and to the use of certain additional ground for reservoir purposes at the site of the old reservoir.

This Butte is geologically not a butte but a basaltic protrusion consisting of characteristic hexagonal basaltic columns, which at the site selected for the reservoir stand very nearly perpendicular, a

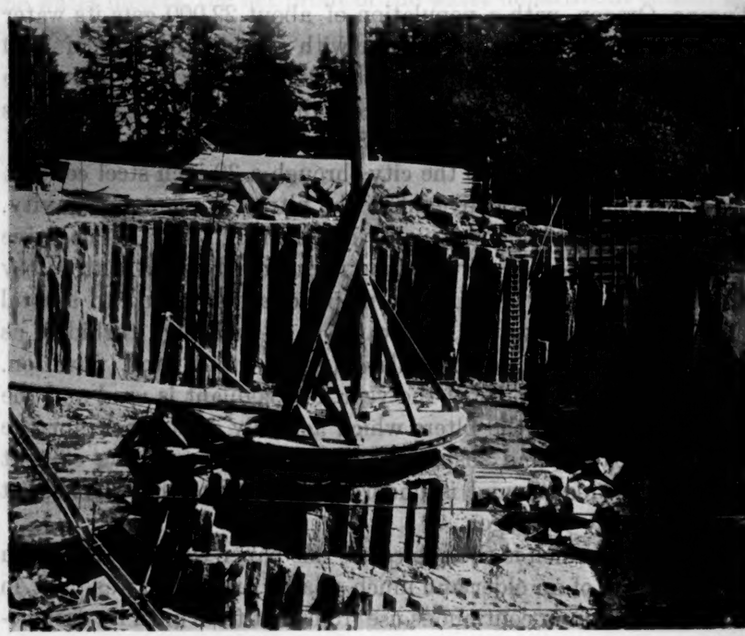

FIG. 1. VIEW SHOWING VERTICAL BASALTIC COLUMN FORMATION ENCOUNTERED IN EXCAVATION FOR COVERED CONCRETE RESERVOIR AT EUGENE, OREGON

fact which had an important bearing on the design adopted for the reservoir.

Within the last dozen years or so two other reservoirs had been built in other sections of the city, both at the same elevation as the old one at the site under discussion and this was another reason for building the new reservoir on the site of the old one.

The excavation for the structure was almost wholly in rock, there being practically no overburden of earth, and since the location was

in a park which could not be made a dumping ground for spoil from the excavation, the disposal of the excavated material was a real problem and it was decided to use as much of it as possible in the reservoir walls.

A gravity type wall was designed and the specifications called for the careful placing of large rocks in the walls, using only as much concrete as was necessary to bed the rock thoroughly in the masonry.

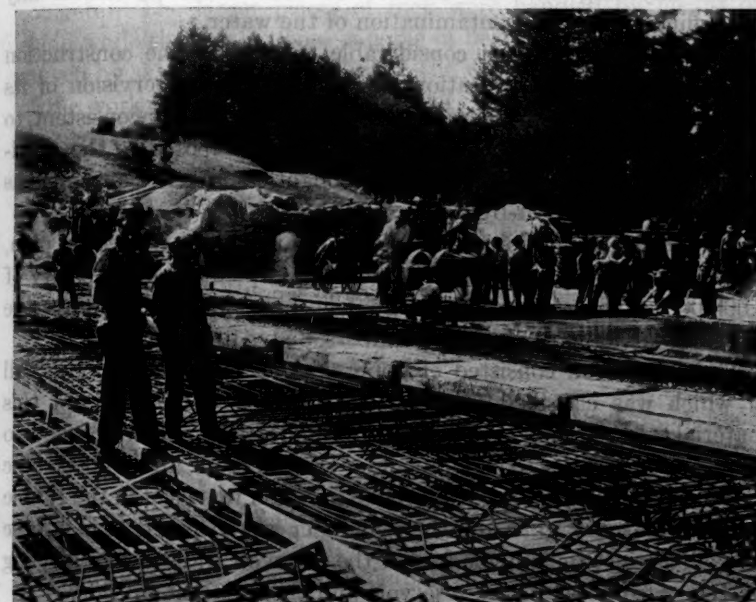

FIG. 2. CONCRETING ROOF SLAB OF COVERED CONCRETE RESERVOIR AT EUGENE, OREGON

Although the rock which had been exposed to direct contact with the water in the old reservoir showed some disintegration, a careful examination of the rock which had been imbedded in concrete seemed to justify the conclusion that the design adopted would result in a permanent, long lived, structure.

There were three factors which entered into the decision to cover the reservoir.

First: The very satisfactory operating experience with a smaller covered reservoir which had been built three years before and the

many favorable comments on the part of water users. Their reasons were mostly esthetic or psychological rather than technical, but were never the less real in their minds.

Second: The location of the reservoir is such that it and the park in which it is situated are visited by thousands of people, both townspeople and tourists, and the old reservoir was a very attractive target into which boys and others threw rocks, apples and in fact almost anything that can be thrown. The cover eliminates any possibility of external contamination of the water.

Third: After spending considerable money in the construction and operation of a purification plant and in the supervision of its operation in order to insure a pure water, it seems inconsistent to store water in open reservoirs where it is ever exposed to the possibility of contamination through the thoughtless, careless or malicious act of a chance passer-by.

The general dimensions of the reservoir are 100 by 170 feet in plan, with a depth of 27 feet to the overflow line, which gives a capacity of 3,000,000 gallons. A partition 15 feet high was built across the reservoir, dividing it into two chambers, 85 by 100 feet.

The excavation consisted of approximately 9500 cubic yards, all of which was classified as rock. About 1500 cubic yards of this material was required for the construction of the road which had to be relocated in order to make room for the reservoir; about 2000 cubic yards of selected material from the excavation was used in the rubble concrete masonry walls and the remainder was disposed of in a loose rock fill against the outside face of the reservoir walls and in leveling up the space between the reservoir and the adjacent hillside.

Extreme care was required in blasting as the excavation approached the finish lines, in order to avoid loosening or shattering the rock face which was to be left in place and used as the reservoir wall and all material which was loosened as a result of blasting was removed.

The specifications provided for building a gravity type concrete wall using Class B concrete (which under these specifications was a 1:3:5 mixture) and placing as much large rock in the wall as possible. In fact, in many places the wall was built quite largely of rock, using concrete instead of mortar for the joints. Concrete was required to be mixed for $1\frac{1}{2}$ minutes and was placed at a fairly wet consistency, having a slump of about 6 to 7 inches. It was conveyed by means of a tower and chutes. The maximum size of the coarse aggregate was 1-inch. Considerable difficulty was experienced in getting concrete

of uniform consistency and there was a good deal of trouble in connection with the use of the chutes, either from their clogging or from the separation of material, all of which resulted in concrete of only fair quality.

The rocks placed in the walls were handled by derrick and were hosed thoroughly with water under considerable pressure, in order to remove any film of dirt which may have adhered and were so placed as to prevent pockets which would be difficult to fill completely with concrete. The larger pieces of rock were handled by means of a chain while the smaller ones capable of being rolled into a skip were moved by skips and hand placed in the wall. We consider this part of the work to have been done in a very satisfactory manner, except that the equipment did not admit of handling the job with sufficient speed at times and the project was considerably delayed as a result.

The walls were designed as gravity sections with no allowance made for uplift. Because of the rigid specifications regarding water-tightness and the care taken in joining the floor with the walls it was not believed that leakage in sufficient quantity to produce pressure would be possible and in this particular case, the foundation was of such character that, if any leakage should occur, it would be impossible for it to develop pressure.

A base was prepared for the floor by the use of a low grade concrete with which the holes and irregularities were smoothed up making a uniform sub-grade on which to place the finished floor of Class A concrete which was 4 inches thick, including a top coat of 1 to 2 mortar, troweled to a smooth finish.

The base of the columns for supporting the roof were poured integral with the floor to a height ranging from a few inches to slightly more than one foot above the floor grade. The variation in the height of the column footings was made to take up the slope in the floor, thereby permitting the use of standard metal forms of uniform length for the columns themselves.

The columns were poured continuously from the top of the base to the bottom of the beam fillets with Class A concrete, which under these specifications consisted of approximately a $1:2\frac{1}{2}:3\frac{1}{2}$ mixture.

The roof was composed of a 10-inch slab of Class A concrete of the beam and girder type, the panels being about 16 feet square. The load assumed in designing this roof slab was 2 feet of earth fill, plus a live load of 120 pounds per square foot.

The beams and girders supporting the roof were built into specially

prepared seats in the reservoir walls. After pouring the top course on the walls in which recesses had been built to receive the ends of the beams and girders, the sides and bottoms of these recesses were troweled to a smooth finish and lined with a ½-inch expansion felt. The same material was used under the edge of the roof slab where it rests on the top of the walls and was intended to permit movement due to expansion of the roof, caused by changes of temperature or moisture conditions. A recent examination of these beams and beam seats seemed to indicate that they are functioning satisfactorily.

Entrance to the reservoir is provided through a small house built in the edge of the roof and directly over the partition wall, thereby giving access to each chamber. The entrance house was equipped on all four sides with steel ventilator panels which provide some circulation of the air lying above the water. The entrance house is provided with a steel door and padlock to make it secure against entrance by unauthorized persons.

A valve house was built as an integral part of the east wall of the reservoir, directly opposite the end of the partition wall, and contains the valves regulating the supply mains and the drain, and a small high pressure line for use in hosing out the interior of the reservoir at time of cleaning. A large dial pressure guage is also installed which indicates the depth of water in the reservoir, and the transmitting end of a Bristol long distance water level recorder, the receiving end of which is installed in the pump station.

Gunite was specified to be placed as required in order to make the reservoir sufficiently water-tight to meet the specification for water-tightness. Because of the irregular surface to be coated and the consequent difficulty of determining the average thickness of the gunite applied, the specifications provided that gunite be paid for by the cubic foot, rather than on an area basis and further specified that one sack of cement would be assumed as producing two cubic feet of gunite on the wall. These data were furnished by the cement gun company and from our observation in connection with this job we believe them to be reliable.

The guniting was done by an inexperienced crew and under rather difficult conditions and cost considerably more than the bid price, although before the work was completed the men had had sufficient experience to get an excellent quality of work at a cost which we estimated at $1.75 per cubic foot.

Where gunite was placed on the original rock left from the excava-

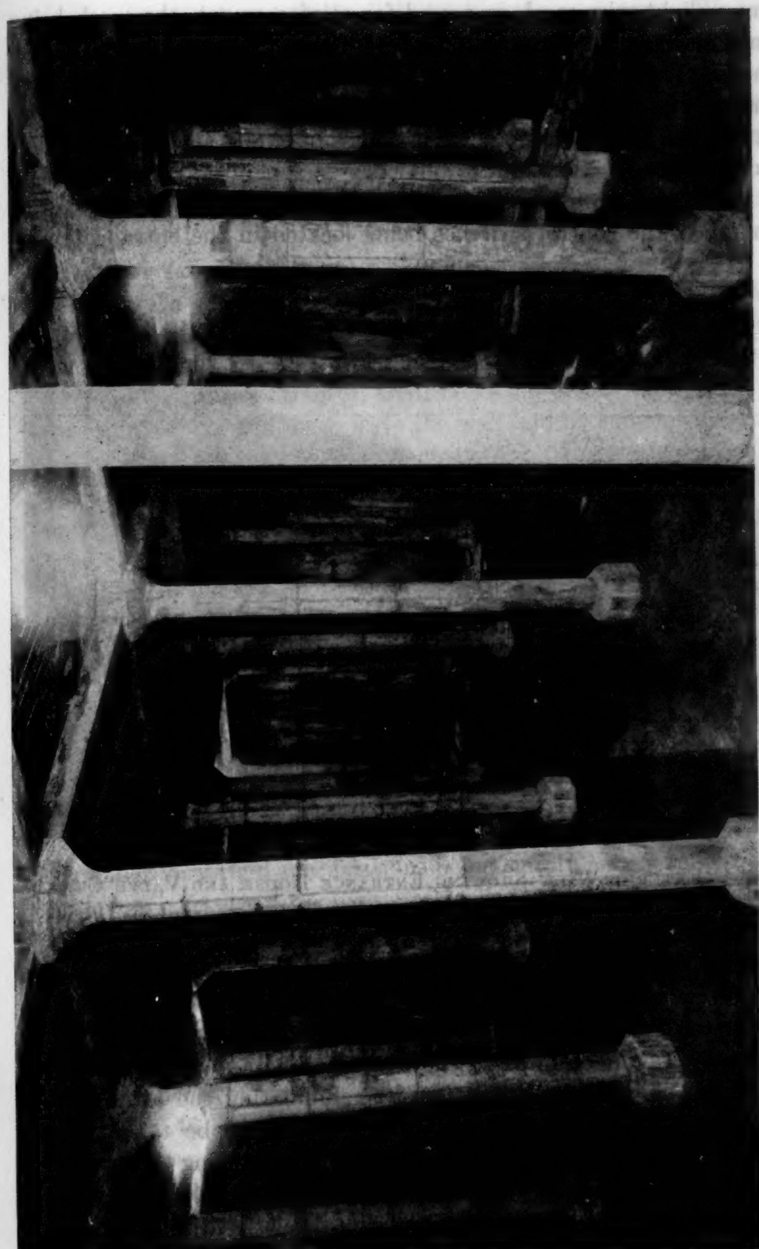

Fig. 3. Interior View of Covered Concrete Reservoir at Eugene, Oregon

tion a light wire mesh was used for reinforcement, the mesh being anchored to the rock by drilling holes and grouting anchor bolts in them. We had no difficulty in getting a satisfactory bond between the gunite and the rock or concrete surface, except where it was attempted to put on too heavy a course of gunite at a single application, in which case it had a tendency to separate and slough off.

Four large lamps in vapor proof fixtures were installed in each chamber, the control switches being located in the entrance house.

FIG. 4. EXTERIOR VIEW SHOWING ENTRANCE HOUSE AND VALVE CHAMBER ON COMPLETED COVERED CONCRETE RESERVOIR AT EUGENE, OREGON

The lighting is not very satisfactory and if we were designing it over again we would try the use of flood lights all installed at the entrance.

The leakage test, preliminary to acceptance, required that the reservoir should be filled to the overflow line and stand full for 24 hours. This was for the purpose of eliminating the absorption of water by the concrete. Readings were then to be taken every 6 hours, for a period of 48 hours, the requirement being that the water surface should not have lowered more than 5/100's of a foot, representing a loss of 6400 gallons.

The first attempt to fill the reservoir was made at the request of

the contractor and against the judgment of the engineers. We were satisfied that it would not even approach the above requirements as to water-tightness and by the time one chamber was filled to the depth of 6 or 8 feet the contractor was willing to stop experimenting and proceed with guniting the interior for making it water-tight. After guniting the interior, the reservoir met the specifications required for the test, with the water surface just below the bottom of the beam seats.

The outer face of the loose rock which was wasted outside of the concrete walls was finished by hand placing, the rocks, in general, being so placed as to present a hexagonal face which though rough gives the wall a very pleasing appearance as of mosaic. This work was done by a sub-contractor, Geo. H. Otten of Portland, after the contractor had attempted to have the wall laid by some of his workmen and was unable to get a satisfactory job. The original specifications were not drawn with the idea of getting as pleasing an appearance as we decided later was desirable, so the specifications were revised and an arrangement made with Mr. Otten who was experienced in this kind of work, to carry it on.

A road leading to the top of Skinner's Butte had been in existence for many years and was a popular drive both for local people and for visitors. The road was within the area to be covered by the new reservoir and it was, therefore, necessary to relocate it. The construction of this road on a new location involved pushing it out on the hillside to such an extent as to require a considerable fill which was made of rock from the excavation. The exterior of this fill was finished by hand placing the outer layer of rock, although it was not done under very rigid specifications being simply a very rough job of riprapping. Hexagonal columns or rocks from the excavation were selected from which to form a guard around the outside of this fill, as will be seen in the figures. The placing of this guard was not included in the contract and was done directly by the city's men. It presents a pleasing effect and one in keeping with the reservoir and its surroundings, and serves the purpose very acceptably.

The total cost of the job, exclusive of engineering and inspection, was $71,066.46. Some of the unit costs which may be of interest are as follows: Excavation, $1.85 per cubic yard. Class A concrete, reinforced in columns and roof, $27.60 per cubic yard. Rubble walls using Class B concrete, $5.40 per cubic yard. Gunite, $1.00 per cubic foot.

The reservoir was designed by W. J. Moore, under the writer's supervision, and the field inspections and drawings were in charge of Mr. Moore, assisted by R. E. Griswold, another engineer in the Water Department.

The contractor was the B. C. Seydel Company of Portland, Oregon, with J. P. Maginnis, Vice-President of the Company, in direct charge of the work.

THE PURIFICATION OF WATER BY ULTRAVIOLET RADIATION

By John Milton Blocher[1]

Little is known regarding the exact nature of radiant energy. It is quite certain, however, that radiant energy is propagated by wave motion.

The fact that the waves are transmitted through a vacuum calls for a carrier. Scientists have for years regarded the ether as the medium by and through which these radiations are propagated. If a time should come when the hypothesis of an ether must be discarded, the change will not materially affect the properties and applications of ultraviolet energy.

The human eye is capable of receiving and recording wave lengths of radiant energy that vary from 390 mμ to 770 mμ. The former figure[2] is the value given for the wave length of visible violet light; the latter is for the wave length of the visible red. The wave length values for the other spectrum colors lie within these limits.

Wave lengths of radiant energy that are shorter than 390 mμ are invisible. Ultraviolet radiation, with its arbitrary subdivisions, (near, intermediate and extreme) occupies this short wave length region of the spectral range of radiant energy.

Since the velocity of radiant energy in space is approximately 3×10^{10} cm/sec., the frequencies may be calculated by dividing the velocity by the wave length. When, for example, the wave length is 400 mμ (the frontier of visible radiation) the frequency has the value 75×10^{13} per second. It follows that the frequencies of radiations in the ultraviolet are much higher, since the wave lengths in this region are shorter than 400 mμ.

It may be said, then, that ultraviolet radiation is characterized by (1) invisibility, (2) short wave length, and (3) high frequencies. They are quite easily absorbed by matter. Relatively few substances allow the radiation to pass through them. Clear fused quartz,

[1] Professor of Chemistry, Baldwin-Wallace College, Berea, O.
[2] One mμ = one-millionth of a millimeter.

fluorite, and ice are known to be highly transparent. Ultraviolet rays have a varied influence upon chemical compounds and upon chemical reactions. They are highly bactericidal. Very few micro-organisms are able to withstand the rays. They have remarkable physiological effects.

The manner in which ultraviolet radiation brings death to the living micro-organism is still a matter of speculation. Investigators are in substantial agreement regarding the following conclusions:

(*a*) The more lethal rays are those with wave lengths within 297 $m\mu$ and 210 $m\mu$.

(*b*) The photochemical laws apply. The active rays are those absorbed by the body acted upon. The total effect is a function of the intensity of the radiation and the time of exposure.

(*c*) The action is direct, and not due to the formation of germicidal substances, such as hydrogen peroxide and activated oxygen.

Some investigators believe that the protein molecule absorbs the ultraviolet, setting up within the protoplasm a resonance resulting in a disruptive vibration.

Results of investigations carried on in the Baldwin-Wallace College laboratory have yielded no evidence that would in any way discredit the above statements. Experiments upon water, both before and after treatment, show that no detectable change of a chemical nature takes place during the treatment.

It is interesting to observe the action of ultraviolet upon microscopic life forms. Euglena mutabilis Schmitz[3] (?) lends itself admirably to this type of experiment, since it is usually found adhering to a surface such as a clay particle. This micro-organism ceases to move on the instant of exposure and seems to be killed instantly by the radiation. During the next second of exposure there is a collapse of body structure and soon after severe disintegration is apparent. It is quite likely that bacteria react in the same manner when exposed to ultraviolet radiation.

THE APPARATUS FOR WATER TREATMENT

Metals, when heated to incandescence, give off ultraviolet radiations. For practical purposes an electric arc may be maintained in a mercury vapor in a partial vacuum that has clear fused quartz

[3] The identity of the microörganism is uncertain. It grows prolifically upon clay in streams near Berea.

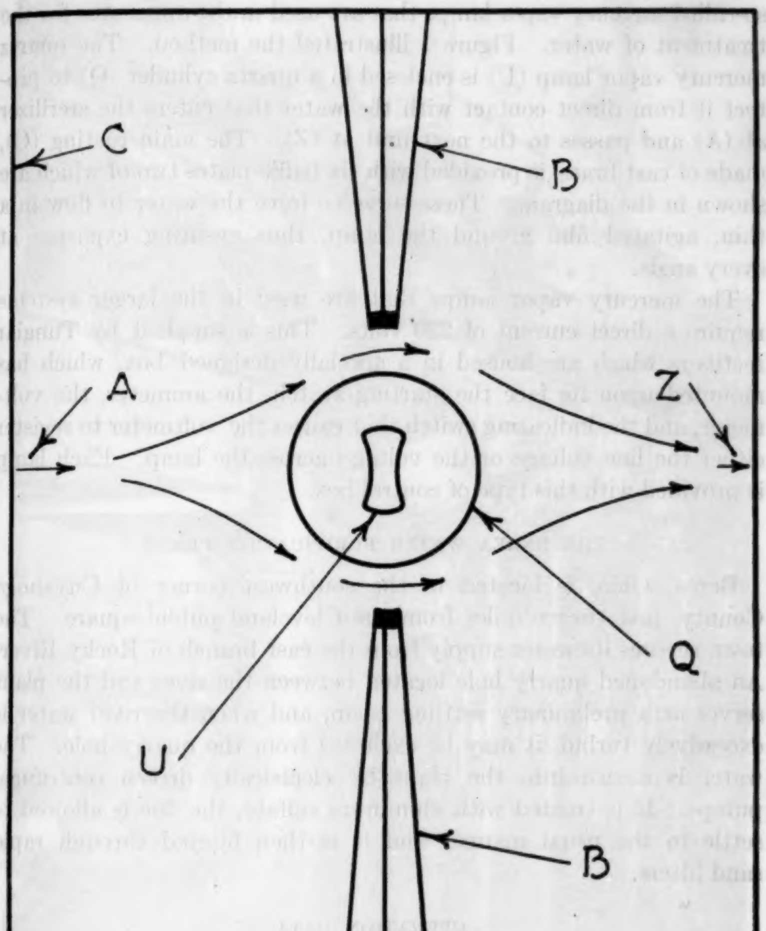

Fig. 1. Diagram of the Interior of One Unit of the Ultraviolet Ray Outfit

C = cast brass box. B = two of the baffles. Q = quartz cylinder. U = mercury vapor lamp. A = inlet. Z = outlet.

as its enclosure. This principle is used in the construction of the so-called mercury vapor lamps that are used in the apparatus for the treatment of water. Figure 1 illustrated the method. The quartz mercury vapor lamp (U) is enclosed in a quartz cylinder (Q) to protect it from direct contact with the water that enters the sterilizer at (A) and passes to the next unit at (Z). The main casting (C), made of cast brass, is provided with six baffle plates two of which are shown in the diagram. These serve to force the water to flow in a thin, agitated film around the lamp, thus ensuring exposure at every angle.

The mercury vapor lamps that are used in the larger systems require a direct current of 220 volts. This is supplied by Tunglar rectifiers which are housed in a specially designed box, which has mounted upon its face the starting switch, the ammeter, the voltmeter, and the indicating switch that causes the voltmeter to register either the line voltage or the voltage across the lamp. Each lamp is provided with this type of control box.

THE BEREA WATER PURIFICATION PLANT

Berea, Ohio, is located in the southwest corner of Cuyahoga County, just twelve miles from the Cleveland public square. The town secures its water supply from the east branch of Rocky River. An abandoned quarry hole located between the river and the plant serves as a preliminary settling basin, and when the river water is excessively turbid, it may be excluded from the quarry hole. The water is drawn into the plant by electrically driven centrifugal pumps. It is treated with aluminum sulfate, the floc is allowed to settle in the usual manner and it is then filtered through rapid sand filters.

OPERATION DATA

Both the light and the water plants at Berea are owned by the municipality. They are practically under the same roof, and they are controlled by a Board of Public Affairs. A superintendent is in direct control of all work concerned with light and water supply. An engineer and a fireman are on duty at the plant at all times. No technically trained attendant is required for the ultra-violet apparatus since the manipulations are simple.

The eight units of ultraviolet lamps have a total capacity of 84,000 gallons per hour or over 2 m.g.d. As a rule, only four of the units

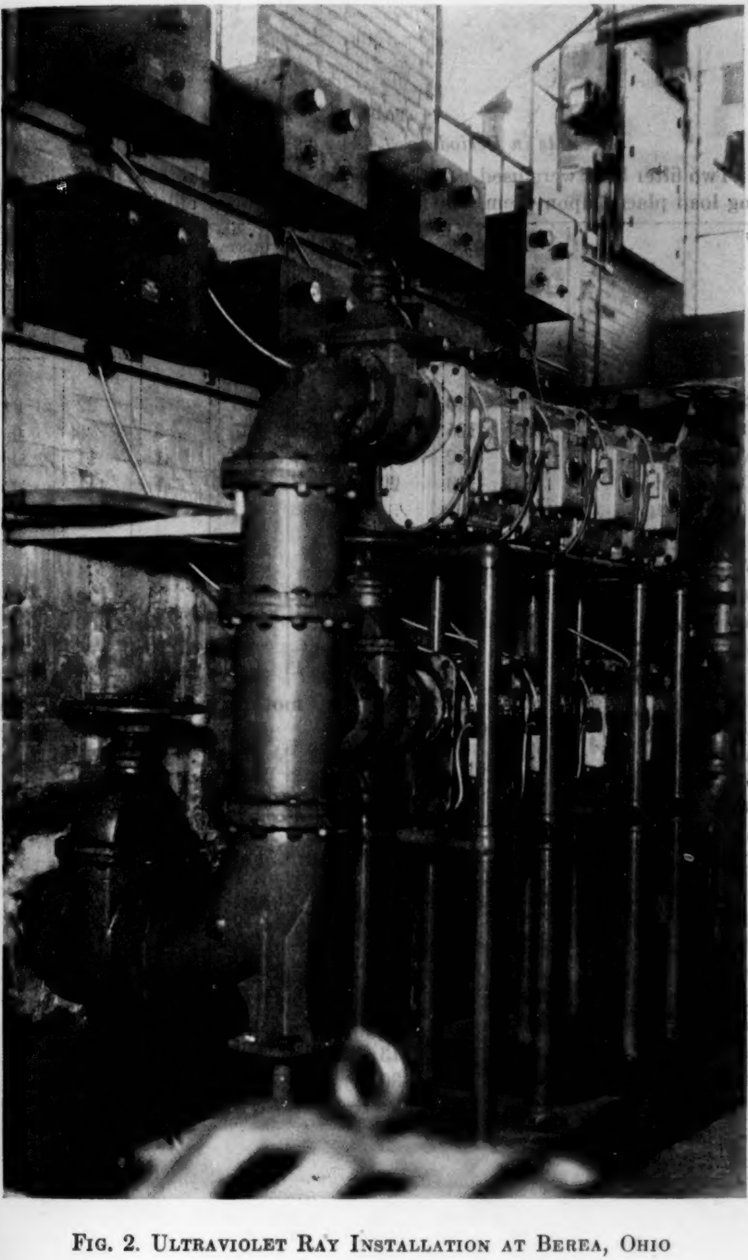

FIG. 2. ULTRAVIOLET RAY INSTALLATION AT BEREA, OHIO

TABLE 1

Results in Period no. 1 (August 1923–July 1925)

Two filter beds were used. They were too small to take care of the increasing load placed upon them, and at intervals the filter effluents were turbid.

DATE	AVERAGE COUNT ON AGAR AT 37°C.				COUNTS FILTERED WATER		COUNTS DISINFECTED WATER	
	Raw water	Applied water	Filtered water	Disinfected water	Maximum	Minimum	Maximum	Minimum
1923								
September	225	140	40	2	65	5	22	0
October	200	125	13	−1	27	3	6	0
November	125	52	6	+1	12	1	11	0
December	185	110	20	+2	43	1	11	0
1924								
January	125	63	18	−1	63	3	2	0
February	105	48	9	−1	31	0	4	0
March	70	29	6	−1	14	1	2	0
April	75	25	6	−1	16	1	2	0
May	70	26	6	−1	14	2	6	0
June	910	330	212	2	800	4	20	0
July	(Flood destroyed the motor-generator of ultraviolet outfit)							
August	165	75	24	2	75	2	25	0
September	160	80	11	2	26	3	6	0
October	240	95	22	7	60	3	30	0
November	90	50	12	+1	26	6	4	0
December	95	42	20	6	45	3	16	0
1925								
January	80	32	8	2	19	2	6	0
February	125	70	28	4	94	1	16	0
March	120	50	20	+2	46	11	7	0
April	55	21	9	4	19	4	14	0
May	120	36	15	4	35	3	19	0
June	85	34	13	−1	19	3	4	0
July	130	70	30	4	70	13	14	0

TABLE 1—*Concluded*

Results of B. coli tests

DATE	FILTERED WATER: Total number of B. coli tests	Number of +, ? and − results*: +	?	−	DISINFECTED WATER: Total number of B. coli tests	Number of +, ? and − results†: +	?	−
1923								
September	22	0	15	7	30	0	0	30
October	9	0	4	5	31	0	0	31
November	8	0	4	4	25	0	0	25
December	7	1	4	2	25	0	5	20
1924								
January	6	1	3	3	31	0	0	31
February	9	0	4	5	22	0	1	21
March	6	0	4	2	22	1	2	19
April	8	0	3	5	25	0	0	25
May	9	0	5	4	24	0	1	23
June	4	0	1	3	25	0	1	24
July	(Flood destroyed the motor-generator of the ultraviolet outfit)							
August	8	2	5	1	31	0	1	30
September	10	4	5	1	22	0	2	20
October	10	1	6	3	27	0	7	20
November	8	0	3	5	18	0	1	17
December	10	2	3	5	29	0	3	26
1925								
January	8	0	3	5	19	0	0	19
February	6	0	5	1	21	0	2	19
March	9	0	5	4	22	0	0	22
April	10	0	5	5	22	0	2	20
May	14	3	9	2	25	3	2	20
June	9	0	6	3	22	0	0	22
July	7	1	4	2	25	1	2	22
Totals	197	15	106	76	543	5	31	507

* + = 7.6 per cent, ? = 53.8 per cent, − = 38.6 per cent.

† + = 1.0 per cent, ? = 5.7 per cent, − = 93.0 per cent.

TABLE 2

Results in Period no. 2 (July 1925–January 1927)

Characterized by increasing filter difficulties. The filters were forced at a rate in excess of 147 million gallons per acre per day when 125 million gallons per acre per day are considered a reasonably safe maximum. The effluent was, as a rule, turbid. Liquid chlorine was used at intervals to supplement the action of the ultraviolet radiation. Acting upon the advice of the Ohio State Board of Health a chlorinator was purchased in July, 1923, when a serious flood destroyed the motor-generator that supplied the direct current for the ultraviolet lamps.

DATE	AVERAGE COUNTS ON AGAR AT 37°C.				COUNTS FILTERED WATER		COUNTS DISINFECTED WATER	
	Raw water	Applied water	Filtered water	Disinfected water	Maximum	Minimum	Maximum	Minimum
1925								
August	155	80	45	20	70	21	50	6
September	90		32	4	64	14	6	0
October	115		42	7	100	17	38	1
November	130	38	18	5	30	10	13	1
December	80	35	11	3	21	4	6	1
1926								
January	60		11	3	29	6	7	0
February	95	47	17	4	26	6	16	1
March	85	39	22	4	47	7	15	1
April	90	38	20	4	32	10	10	1
May	60	29	16	2	40	6	6	0
June	60	28	12	2	22	6	6	0
July	80	36	6	3	13	1	13	0
August	70	50	17	2	29	3	13	0
September	155	70	30	5	46	15	21	0
October	145	70	27	5	41	17	19	1
November	190	90	39	6	65	14	12	2
December	130	46	12	6	34	17	10	3

TABLE 2—*Concluded*

Results of B. coli tests

DATE	FILTERED WATER				DISINFECTED WATER			
	Total number of B. coli tests	Number of +, ?, and − results			Total number of B. coli tests	Number of +, ?, and − results		
		+	?	−		+	?	−
1925								
August	10	0	6	4	24	8	2	14
September	10	0	6	4	21	0	0	20
October	9	4	4	1	25	0	6	19
November	8	2	4	2	23	0	2	21
December	9	0	3	6	22	0	0	22
1926								
January	8	1	5	2	20	0	0	20
February	7	0	5	2	21	1	0	20
March	7	0	6	1	23	0	1	22
April	9	0	7	2	23	0	0	23
May	6	0	3	3	24	0	0	24
June	8	0	4	4	22	0	0	22
July	6	0	0	6	20	0	1	19
August	7	0	1	6	24	0	1	23
September	8	2	3	3	26	1	4	21
October	9	0	4	5	29	0	6	23
November	8	1	3	4	24	0	5	19
December	5	0	2	3	26	0	6	20

TABLE 3

Results in Period no. 3 (January 1927–August 1928)

During this period two new filter beds were placed in operation, Tunglar rectifiers replaced the old motor-generator as a source of direct current, and four new units of ultraviolet ray apparatus were installed. They were built in series and placed parallel with the older units. See figure 2.

DATE	AVERAGE COUNTS ON AGAR AT 37°C.				COUNTS FILTERED WATER		COUNTS DISINFECTED WATER	
	Raw water	Applied water	Filtered water	Disinfected water	Maximum	Minimum	Maximum	Minimum
1927								
January	190	75	53	3	43	7	8	0
February	185	39	5	−1	11	2	3	0
March	195	60	9	−1	20	1	4	0
April	130	50	7	−2	18	2	4	0
May	80	45	8	−2	15	3	7	0
June	170	65	7	−2	15	3	5	0
July	190	100	22	3	41	6	10	0
August	125	50	9	−1	14	3	4	0
September	210	105	34	24	90	14	50	0
(Encountered filter difficulties)								
October	190	55	11	1	20	7	4	0
November	155	44	4	1	9	0	3	0
December	110	55	6	1	14	4	3	0
1928								
January	370	185	4	1	10	0	12	0
February	120	55	2	1	12	0	4	0
March	130	40	4	1	12	0	3	0
April	75	29	6	1	21	0	4	0
May	55	24	2	0	8	0	3	0
June	65	32	2	1	7	0	3	0
July	170	50	5	1	16	0	5	0
August	60	27	4	1	11	0	2	0

TABLE 3—*Concluded*

Results of B. coli tests

DATE	FILTERED WATER: Total number of B. coli tests	FILTERED WATER: Number of +, ? and − results*: +	?	−	DISINFECTED WATER: Total number of B. coli tests	DISINFECTED WATER: Number of +, ? and − results†: +	?	−
1927								
January..........	7	0	3	4	31	0	4	27
February..........	6	0	1	5	20	0	0	20
March..........	7	0	1	6	23	0	1	22
April..........	8	0	2	6	21	0	0	21
May..........	12	0	2	10	18	0	2	16
June..........	8	0	4	4	22	0	0	22
July..........	9	0	3	6	25	0	1	24
August..........	4	0	0	4	20	0	0	20
September..........	9	1	4	4	26	0	5	21
October..........	7	0	3	4	21	0	0	21
November..........	8	0	0	8	22	0	0	22
December..........	8	0	3	5	23	0	0	23
1928								
January..........	9	0	5	4	23	0	0	23
February..........	9	0	2	7	22	0	0	22
March..........	9	0	4	5	24	0	0	24
April..........								
May..........	9	0	0	9	23	0	0	23
June..........	8	0	1	7	20	0	0	20
July..........					24	0	2	22
August..........	6	0	0	6	23	0	0	23
Totals..........	143	1	38	104	431	0	15	416

* + = 0.7 per cent, ? = 26.5 per cent, − = 62.8 per cent.

† + = 0.0 per cent, ? = 3.0 per cent, − = 97.0 per cent.

are used since the pumpage seldom exceeds 800,000 gallons per day. The arrangement of the units in parallel series of four has distinct advantages. Four units may be thrown out of service, and the quartz cylinders may be cleaned without interrupting the flow of water. The cylinders are cleaned at intervals of three or six weeks depending on the quality of the water treated. The time of exposure to the ultraviolet may be increased by sending the water through the two series.

The operation record shows that during May, 1929, the ultraviolet ray outfit was in use for a total of 692 hours, 20,535,000 gallons of water were pumped, 4 of the 8 lamps were used, and the meter on the outfit indicated that 4090 K.W. were consumed by the 24 Tunglar rectifier lamps and the 4 mercury vapor lamps. The cost, therefore, is not prohibitive.

The cost of mercury vapor lamps has been reduced to the vanishing point. The Tunglar rectifiers supply a very even flow of current to the lamps, and not one has burned out since the rectifiers were installed a year ago.

RESULTS

The results obtained at Berea may be classified into three periods, shown in tables 1, 2 and 3.

CONCLUSIONS

1. The discouraging results obtained in the second period, due entirely to abnormal conditions, should not be charged against the ultraviolet method.

2. The method is particularly recommended for use in plants where the retention period of the disinfected water is short.

3. A comparison of the percentages of positive, questionable and negative results of tests on the filtered water with those recorded for the disinfected water (tables 1 and 3) lead to the conclusion that ultraviolet radiation is particularly effective against gas-forming micro-organisms.

4. Aftergrowths are negligible. Sixty per cent of the tests were made on samples secured from taps located a half mile or more from the plant. Many of them were taken from dead ends.

5. The results obtained to date (July, 1929) are similar to those obtained in the third period.

6. There is no danger of overdosage, and the method normally produces a safe water absolutely free from disagreeable tastes.

THE DISSOCIATION OF WATER IN STEEL TUBES AT HIGH TEMPERATURES AND PRESSURES[1]

By C. H. Fellows[2]

The advent of higher pressures and temperatures in the modern steam generating plant has made necessary a better understanding of the chemical phenomena associated with the production of steam under these new conditions. This is true not only in the large electricity generating plants where the production of steam receives a degree of attention comparable with that given the accumulation and distribution of its one product—electrical energy; but it is true, also, in steam plants of both large and small manufacturing organizations where plant design is showing a marked tendency to keep pace with the development of the art.

Boiler scale, the steam producers' greatest enemy, has now to be fought in a new way. The weapons used are not new, but a new appreciation of the potentialities of those weapons exists, whereby, of necessity, the old rule-of-thumb methods of treating water to prevent scale in low pressure boilers has given way entirely to complete scientific treatment based upon the chemistry of the changes that the water and its soluble salts undergo under steaming conditions in the more modern higher pressure boilers. Associated with the problems of scale prevention are those of embrittlement and corrosion, both of which have new aspects in modern steam generation. In the lower pressure type of boiler where the water, either treated or untreated, caused a precipitation of scale on the inner surfaces of the drums and tubes, corrosion was usually not serious. If it developed, little damage was done, and often a corrosive condition was not discovered until the units were dismantled to make room for new equipment.

In many of the modern high pressure boilers, (by high pressure we have reference to operation above 250 pounds per square inch gage) the feedwater is scientifically treated to prevent scale, embrittlement,

[1] Presented before the Boiler Feed Water Studies Committee Session, the Toronto Convention, June 25, 1929.

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and corrosion. The treatment is also designed to prevent "carry over" or that condition which results in the production of very wet steam. Still other boilers of high pressure design operate solely upon untreated distilled water. In the first case where treatment is used the superheaters only are unprotected against any corrosive tendencies of the water, whereas in the latter instance the whole boiler equipment, economizer, drums and tubes, and the superheater have no protection whatever. In installations of this character the corrosiveness of pure water becomes a problem of primary importance. Continued operation of boiler equipment under such conditions can be safely maintained only by the application of preventive measures or a well founded sense of security based on knowledge of the chemistry of water under those conditions and a knowledge of the type and rate of progression of the corrosion observed. Pure water will dissolve iron, and when dissolved oxygen is absent a galvanic type of corrosion will occur. A significant question is, how serious may the results of corrosion become?

During the initial survey of the feedwater conditions in a new power plant, the boilers of which were to operate on untreated distilled water, advantage was taken of the opportunity to study in some degree the changes that water and steam undergo from the time the water enters the economizers until it leaves the boiler as superheated steam. If we assume that the last traces of oxygen dissolved in the feedwater can not be removed, such a study would reveal at what point in the boiler the greatest consumption of oxygen occurs. It was also thought that changes in the alkalinity of the water could, through the medium of the pH system of measurement, be related to the degree of corrosion to be expected in different parts of the boiler system after a period of operation. The observations of greatest interest, however, were those indicating the presence of hydrogen in both the saturated and superheated steam as well as traces of this gas in the water as it entered and left the economizers. The superheated steam showed more hydrogen than did the saturated steam. The actual amounts were too small to cause alarm, but they did indicate the probable occurrence of a phenomenon that has heretofore received very little attention—the dissociation of steam in contact with steel at high temperatures A large number of observations showing the presence of hydrogen, served to substantiate the findings of the first tests, and to lend weight to the belief that

dissociation of the steam may actually occur under conditions similar to those present in the equipment in question.

The significance of these indications of dissociation of steam in the boiler equipment of this plant is that unless the steam flow is correctly distributed between the tubes of the superheater and unless combustion is completed before furnace gases reach the superheater tubes some of these tubes may reach temperatures at which oxidation due to the phenomenon of dissociation may occur.

In view of the possibility of the use of even higher temperatures than 700°F. for superheated steam, it seemed desirable to obtain information relative to the dissociation of steam in contact with hot metal, and to relate such data as might be obtained to the utility of steel under the proposed conditions.

Toward this end an investigation was made in which the degree of dissociation of steam in contact with low carbon steel superheater tube ($c = 0.10$) could be measured and the trend of the reaction involved could be studied while the temperature of the metal in contact with the steam was varied. Later the tests were repeated using chrome-steel tubes of the same dimensions in which the chromium content was 16.35 per cent by weight of the metal constituting the tube.

Each tube used in the test was exactly 27 inches long, 1.625 inches internal diameter, and presented an area of 0.98 square foot for reaction with steam. The tubes during the test were attached to the rest of the system by means of specially shaped Monel metal caps.

The apparatus used is shown in figure 1 and was constructed to make possible the following procedure: (*a*) Take a sample of steam, the state point of which is known; (*b*) determine the gases carried by that sample; (*c*) take a similar sample of steam and pass it over a heated metallic surface (the tube under test in this instance); (*d*) determine the state point of the steam leaving the surface and (*e*) finally separate, measure, and analyze the gas evolved as a result of the reaction between the steam and the heated metallic surface.

It was necessary to alter the apparatus slightly in order to obtain the desired state point of the steam entering the tube under test. When operating with saturated steam at 425 pounds per square inch gage pressure the apparatus was arranged as shown on figure 1. When superheated steam was used at the same pressure, an additional tube of chrome-steel was placed in the steam line, shown on figure 1,

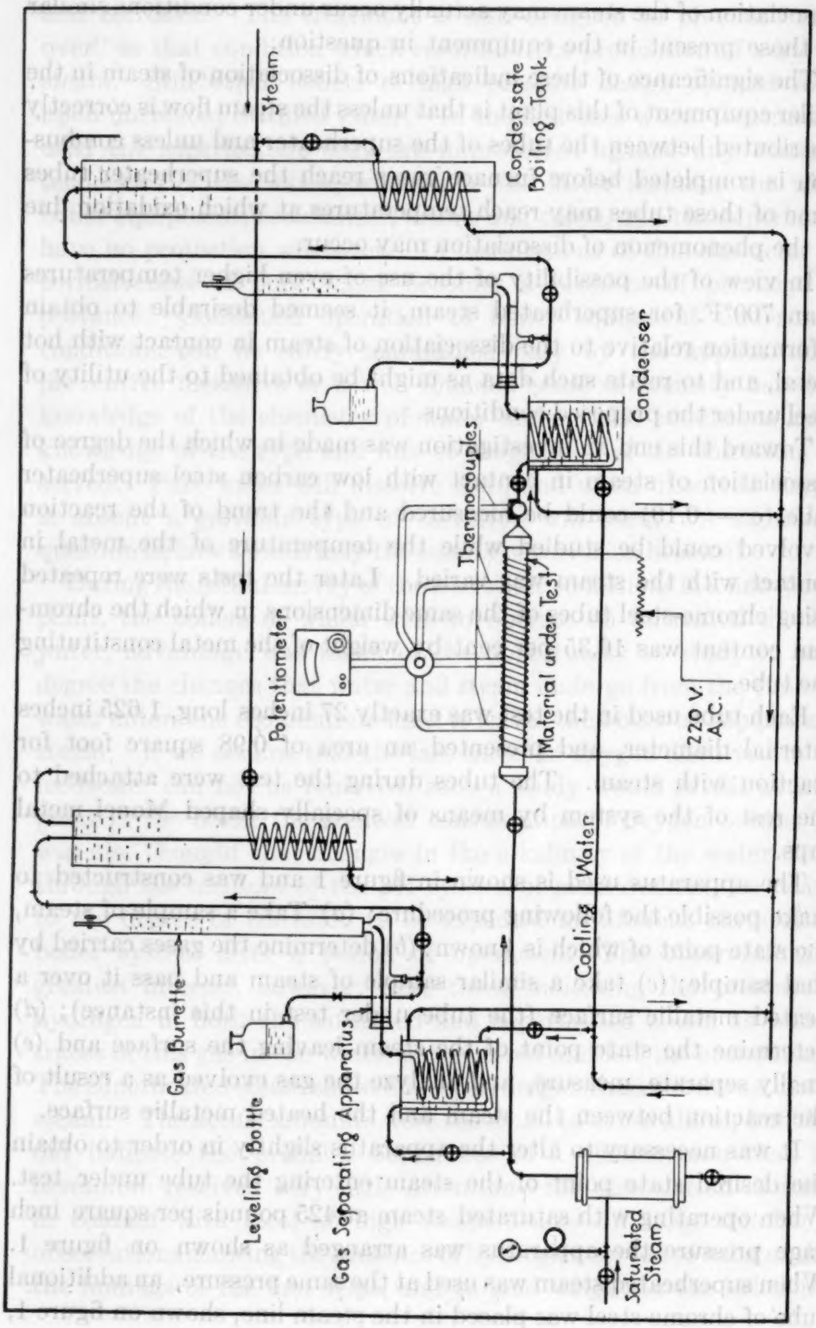

FIG. 1.—ARRANGEMENT OF APPARATUS FOR EXPERIMENTS

between the inlet end of tube under test and the steam separator for the purpose of superheating the steam. This tube was maintained at 1000°F. at the center section, thus causing the steam passing through it to be superheated without the evolution of an appreciable quantity of gas as a result of metal and steam reaction. A thermocouple was placed in a well at the inlet end of the tube under test to permit the determination of the state point of the steam before passing into the tube.

When operating the apparatus with saturated steam at various pressures a reducing chamber was placed in the steam line ahead of of the steam separator shown on figure 1.

The inside surface of the tube of the material to be tested was first pickled. This was done in an effort to obtain surfaces of like character in each test. Dilute hydrochloric acid was used with the low-carbon steel tubes and concentrated hydrochloric and dilute nitric acids with the chrome-steel tubes. The pickling was done immediately before a test. The tube was placed in position in the apparatus and filled with nitrogen at atmospheric pressure. This prevented any change in metal surface condition due to any oxidation which might take place while adjusting the apparatus prior to the actual test.

The tube under test was heated electrically, being brought up to and held constant at some predetermined nominal temperature. This nominal temperature was regulated by that at the middle section of the tube, which was about the average temperature of the tube, being higher than that at the inlet and lower than that the outlet end. (See table 1.) Tube temperatures were also taken at one-fourth and three-fourths the length of the tube as "inlet" and "outlet" tube temperatures respectively. After the temperature of the middle section of the tube had become constant, steam at the desired state point was allowed to blow through the tube for an instant to sweep the internal surface clear of nitrogen. The rate at which this steam passed through the tube was then adjusted to approximately 0.20 pound per minute by determining the weight of the condensate flowing out of the condenser per unit of time. The adjustment of the steam flow required about 5 minutes and any gas evolved during this time was discarded.

The steam passed out of the tube under test, over a thermocouple welded into the bottom of a thermometer well, through a throttling needle valve and thence into a condenser. After the condensation

TABLE 1

Summation of test data

Test number	A	B	D	E	H	I	J	K	L	M	N	O	P	Q	S
Tube number	A-4	B-5	B-8	B-4	C-5	C-4	C-6	A-2	A-1	B-6		B-2			
Tube material	Steel	Steel	Steel	Steel	Chrome steel	Chrome steel	Chrome steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel
Tube temperature, °F., average:															
Inlet End (¼ length of tube)	1,100	967	910	954	1,225	1,094	1,248	1,108	1,024	939	950	1,043	922	914	980
Center	1,200	1,012	1,200	1,100	1,305	1,200	1,397	1,200	1,100	998	1,200	1,200	1,200	1,200	1,200
Outlet end (¾ length of tube)	1,312	1,040	1,276	1,113	1,340	1,285	1,490	1,266	1,177	1,048	1,330	1,360	1,316	1,334	1,270
Steam temperature, °F., average:															
Inlet	454	454	See figure 6	452	451	453	455	767	780	731	338	388	422	452	452
Outlet	1,143	955		904	1,072	1,043	1,226	1,061	963	865	936	1,036		942	909
Steam pressure, pound per square inch gauge, average	422	423		417	415	420	425	420	419	420	100	200	300	418	420
Steam rate, pound per minute, average	0.20	0.19		0.20	0.19	0.19	0.16	0.19	0.18	0.18	0.20	0.20	0.20	0.20	0.20
Rate of gas evolution after 4 hours test, cc. per 3 minutes	278	3		13	0	0.2	2.5	48	27	2	60	60	34	45	
Gas analysis, per cent by volume, average for entire test period:															
CO_2	0.9	1.5		0.6	0.3	1.2	0.6	0.6	0.6	0.2	0.3	0.4	0.3	0.5	0.2
O_2	0.5	0.4		0.3	4.2	1.0	2.9	0.4	0.8	1.5	0.2	0.1	0	0	0.7
H_2	97.6	96.0		93.8	70.2	78.6	80.0	95.9	94.5	89.8	97.5	97.1	95.5	97.3	95.3
CO	0	0		0.4	0.3	0	0	0.2	0.2	0.3	0	0	0.3	0.1	0.1
N_2	1.0	2.1		4.9	25.0	19.2	16.5	2.9	3.9	8.2	2.0	2.4	3.9	2.1	3.7
Pickling reagent	Dil. HCl	Dil. HCl	Dil. HCl	Dil. HCl	Dil. HNO_3	Dil. HNO_3	Dil. HNO_3	Dil. HCl	Dil. HCl	Dil. HCl	Dil. HCl	Dil. HCl	Dil. HCl	Dil. HCl	Dil. HCl

of the steam the non-condensable gases that remained entrained in the condensate were carried into the gas separating apparatus where they displaced the water from the gas measuring burette. The gas was measured at atmospheric pressure at 3-minute intervals. The displaced water passed out of the burette, together with the normal flow through the apparatus, into a steel tank. This tank was filled at the start with gas free water by boiling distilled water in the tank. As the test progressed the condensate was passed into the bottom of the tank at a slow rate, displacing the gas free water through an

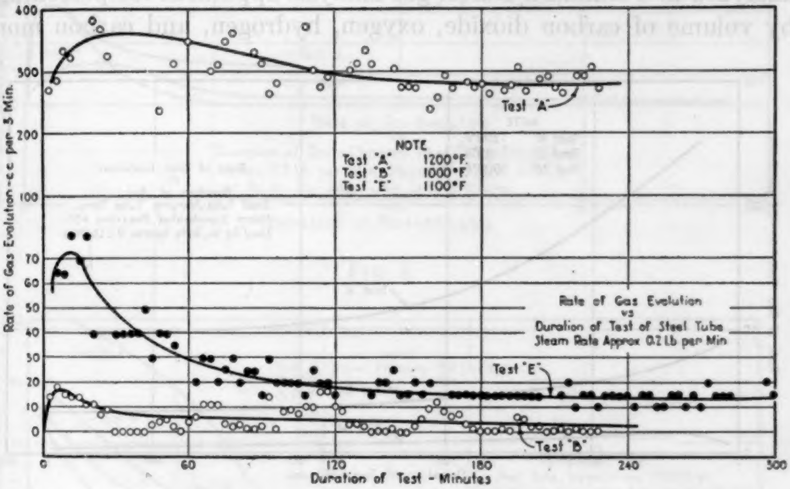

FIG. 2

outlet at the top of the tank. Thus the condensate was collected and subsequently boiled while held out of contact with the atmosphere.

The boiling of the condensate in the steel tank was done at the completion of the test and the steam was condensed in an inverted separatory funnel, the mouth of which was immersed in a vessel of cold water. This boiling liberated the gases that had been redissolved during the first condensation and which had not been removed in the separator. The gases liberated were collected in the separatory funnel and their volume determined.

Thermometers were placed on the gas burettes and separating apparatus for the purpose of obtaining gas temperatures for making gas volume corrections to standard conditions and in order that the

temperature of the condensate, at the point of separation, might be maintained constant.

A condenser, gas separator and volume determining apparatus, duplicate of the apparatus just described, were used to determine the volume o f non-condensable gases in a sample of steam from the same source as that which was passed through the heated tube.

Samples of the gas liberated in passing the steam over the heated surface were taken at various times. These samples were collected in a standard gas sampling apparatus. The gas samples were analyzed in a standard Burrel gas analysis apparatus for percentage by volume of carbon dioxide, oxygen, hydrogen, and carbon mon-

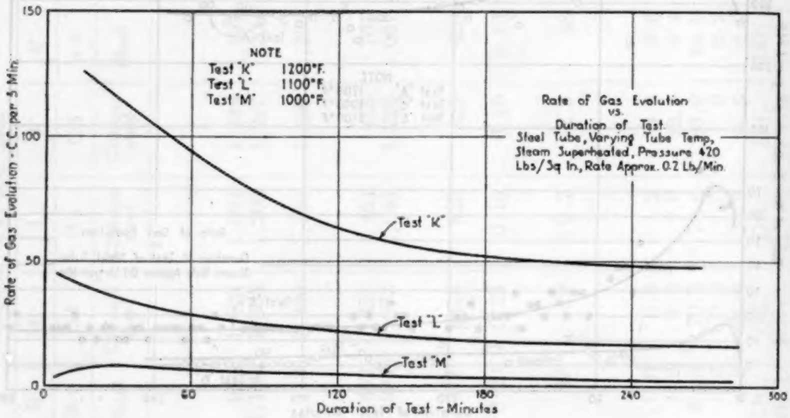

FIG. 3

oxide. The percentage of nitrogen was taken as the difference between the sum of the percentages of the determined gases and 100 per cent A test was made for methane and its absence was indicated. The table at the end of this paper shows the conditions prevailing during each of the tests described herein.

Tests A, B, and E (fig. 2) were conducted to determine the effect of metal temperature and duration of test on the rate of gas evolution when passing saturated steam at approximately 420 pounds per square inch gage pressure, (temperature 450°F. approximate) through a low-carbon steel tube at a rate of approximately 0.20 pound per minute. This rate of flow corresponds to about 23 feet per minute. Subsequent tests under these conditions have led us to believe that the temperature measuring equipment used during test A

was in error and that actually the temperature of the tube at the center was between 1300°F. and 1400°F. Curve A on figure 2, therefore, probably represents the rate of gas evolution at temperatures somewhat higher than 1200°F.

Tests K, L, and M (fig. 3) were conducted to determine the effect of metal temperature and duration of test on the rate of gas evolution when passing superheated steam at approximately 750°F. and 420

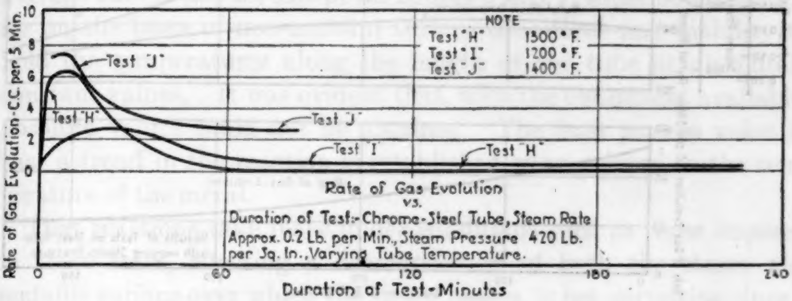

FIG. 4

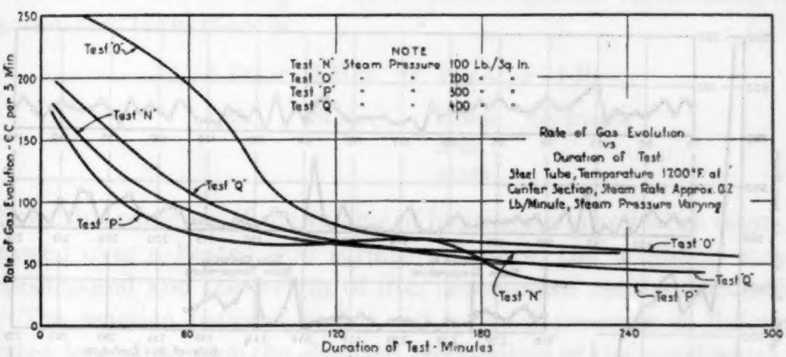

FIG. 5

pounds per square inch gage through a low-carbon steel tube at a rate of approximately 0.20 pound per minute.

Tests D, N, O, P and Q (figs. 5 and 6) were conducted to determine the effect of steam pressure and duration of test on the rate of gas evolution using a low-carbon steel tube with the temperature of the central section at 1200°F. The steam rate was approximately 0.20 pound per minute for these tests with the exception of Test "D" (shown on figure 6) when it was approximately 0.7 pound per minute.

Test "S," figure 7, was made to determine the effectiveness of the oxide scale in preventing continued decomposition of metal and was

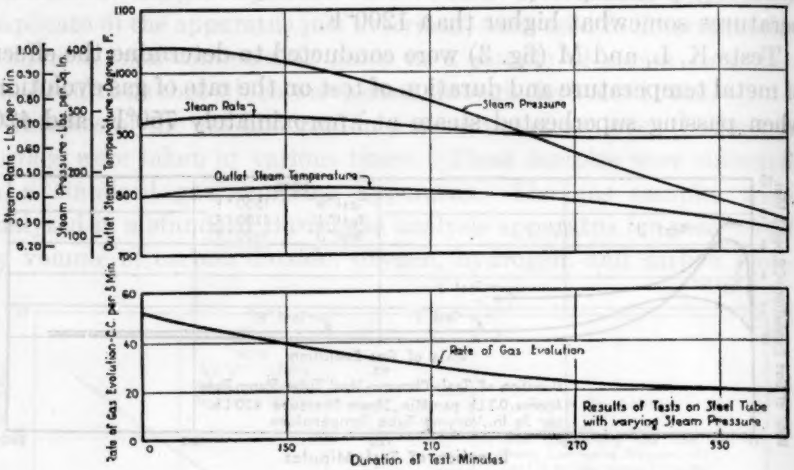

FIG. 6

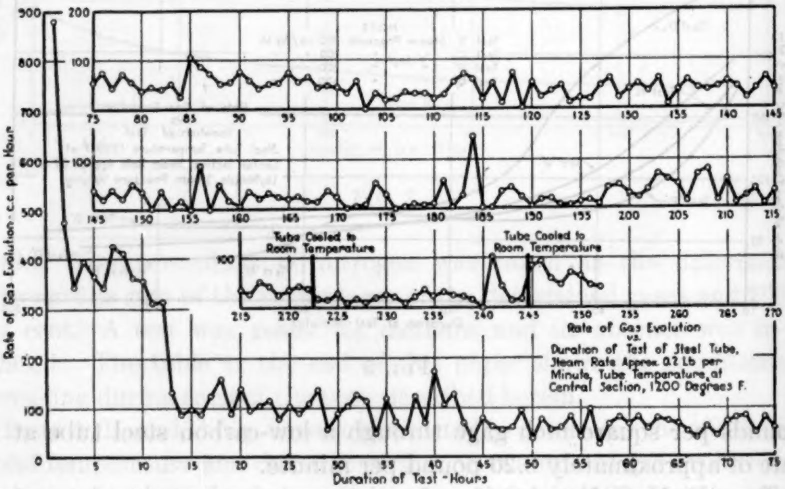

FIG. 7

prolonged to 250 hours. The temperature of the steam was about 450°F. with a pressure of 420 pounds per square inch gage. The nominal tube temperature at the center was 1200°F.

Tests H, I and J (fig. 4), were conducted to determine the effect of metal temperature and duration of test on the rate of gas evolution when passing saturated steam at a pressure of approximately 420 pounds per square inch gage (temperature about 450°F.) through a chrome-steel tube at a rate of approximately 0.20 pound per minute.

The erratic variations in volumes of gas measured during successive readings in each of these tests, and which are not shown by the average curves herein, except on figures 2 and 7, must be accounted for on the basis of non-uniform surface conditions and inability to hold the temperatures along the length of the tube at absolutely constant values. It was evident that, with the equipment available, absolute values could not be obtained. The data possess value in that a trend in the reaction is established when related to the temperature of the metal.

That reactions take place under conditions such as those imposed in these tests, effecting a decomposition of both the steam and metallic surface over which the steam passes, is not surprising since a commercial method of producing hydrogen consists of passing steam over heated iron turnings. The chemical equation representing the action that takes place is:

$$3\,Fe + 4\,H_2O \rightarrow Fe_3O_4 + 4\,H_2$$

Iron	Steam	Black iron oxide	Hydrogen

From this equation, if the volume of hydrogen evolved when steam is passed over a heated iron surface is known, the weight of steam decomposed and the weight of iron decomposed can be calculated.

The reaction between steam and a metal proceeds at different rates depending upon the chemical composition of the metal which is used in the reaction, the condition of the surface, temperature of the surface of the metal in contact with the steam, temperature of steam, moisture in steam, and the rate at which steam is passed over the surface. It has been definitely shown by this series of tests that the rate of gas evolution and metal decomposition decreases as the oxide coating increases in thickness. This may be considered as a change in surface condition.

In any test, no conclusions can be drawn from the rate of gas evolution until the test has progessed sufficiently far to render the inner surface of the tube practically uniform. In this set of tests

this condition is evident after about 4 hours of test. This is shown by the flattening of the rate of gas evolution versus duration of time curves.

The saturated steam referred to in this work probably contained 1 to 2 per cent moisture.

The effect upon the rate of gas evolution resulting from varying the steam pressure between the limits shown on figure 5 is evidently too small to be determined with the test apparatus used in this investigation. The inconsistency of the results shown on figure 5 probably results from the more marked effect upon the gas evolution

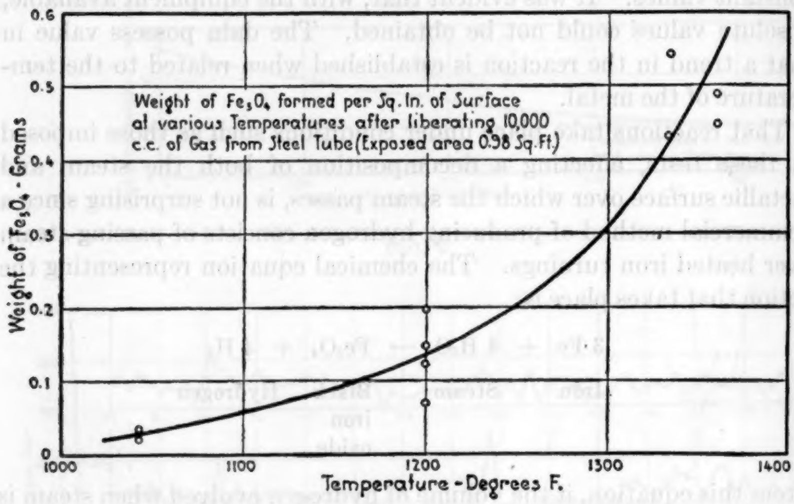

FIG. 8

of the non-uniformity of the tube surfaces and also from the fact that the individual temperatures along the length of the tube could not be held sufficiently constant to show the result of the less pronounced effect of different steam pressures.

No conclusions can be drawn from those data shown on figure 6 which indicate a decrease in the rate of gas evolution with a decrease in steam pressure. This condition was probably caused by a change in the surface condition of the tube.

In order to throw some light on any relationship that might exist between metal temperature and the rate of metal decomposition, the data on figure 8 were calculated. This was done by determining the weight of iron oxide (Fe_3O_4) formed on the inside surface of a

section of the tube which had been subjected to a known temperature. To reduce the weight of oxide formed to a convenient basis of gas liberation, the weights were corrected to the basis of a total of 10,000 cc. of gas evolved from a tube surface of 0.98 square foot.

The conclusions to be drawn from this work are:

1. The rate of decomposition of metal increases as the temperature of the surface over which the steam passes is raised (figs. 2, 3 and 8).

2. The rate of decomposition of metal decreases as the thickness of the oxide formed on the surface increases. There is no evidence that this oxide attains sufficient thickness or imperviousness to completely protect the metal from further oxidation (figs. 2, 3, 6 and 7).

3. For *practical considerations* the variation in steam pressure within the limits used appears not to affect the rate of decomposition of the metal over which it passes.

4. The decomposition of low-carbon steel under the conditions of the test proceeds at a much faster rate than that of chrome-steel used under the same conditions.

In relating these data and conclusions to conditions that actually obtain in the power plant in which this investigation was carried out, the following comparison of test conditions and plant conditions is of interest.

ITEM	TEST CONDITION*	PLANT CONDITION (SUPERHEATER)
Steam pressure, pounds per square inch	422	422 (approx.)
Steam temperature, °F., average	798 (inlet)	700
Velocity of steam, feet per minute	23	851†
Temperature of metal, °F., at center of tube	1,200‡	707§
Flue gas temperature, °F., average in superheater pass		1,100

* For test A—figure 1.

† For steam output of from 150,000 to 350,000 pounds per hour.

‡ Temperature at center of tube was probably higher than 1,200°F. in test A.

§ For steam output of from 180,000 to 300,000 pounds per hour measured on tube 2 feet ahead of outlet header.

There are two very significant differences between the test conditions and those obtaining in actual practice; (1) the difference in steam velocity and (2) the difference in metal temperature.

It was stated earlier in this paper that in initial survey of the feedwater conditions in the plant in which this investigation was carried out, the presence of hydrogen was definitely established. It was also established that the amount of hydrogen found per 1000 pounds of steam was greater in the case of the superheated steam than in the case of saturated steam, which fact indicated that the reaction causing the evolution of hydrogen was confined largely to the superheater of the boiler. Subsequent examination of many of the superheater tubes of the test boiler failed to reveal the presence of black iron oxide that accompanies the dissociation of steam under these conditions. The explanation considered adequate for this fact is that the amount of hydrogen found to have been evolved by the passage of the steam through the superheater over a period of somewhat over one year of operation was too small (8 cc. per 1000 pounds of water) to have left effects on over 4000 square feet of surface of a magnitude that might be detected.

The curve on figure 8 indicates that at metal temperatures as low as those measured on the superheater tubes of a boiler no dissociation of water is likely to occur. It is a well known fact, however, that unburned combustible gases find their way through the various passes of a modern boiler and ignite spontaneously at points where normally no flame exists. This phenomenon has been observed many times in the superheater pass of boilers, and may offer an explanation for the actual existence, even though momentary, of tube temperatures of that order necessary to cause the dissociation of steam.

About the same time these studies were being conducted other investigators were looking into the possibility of the occurrence of hydrogen in steam with a view to correlating its presence with the utility of low-carbon steel for superheater work. In one particular instance that came to the writer's attention the temperature conditions were such that dissociation should have occurred but no indications of hydrogen could be definitely established. Inquiry revealed that the steam velocity in this case (about 3000 feet per minute) was considerably higher than that of our experience.

Although in the three situations discussed (namely, (1) that situation last mentioned, of high velocity, (2) the situation existing where the writer found hydrogen in superheated steam and (3) those conditions surrounding the test discussed herein where relatively large volumes of hydrogen were found) all other conditions such as temperature and pressure were not the same, there, nevertheless, appears

to be a relation between steam velocity and the development of hydrogen through dissociation of steam. Expressed very roughly we find at steam velocities approximating 3000 feet per minute, no hydrogen, no dissociation and consequently no oxidation of the metal from this cause. At velocities approximating 850 feet per minute small quantities of hydrogen become evident and finally at velocities of the order of 25 feet per minute we get relatively large quantities of hydrogen and severe corrosion of the low-carbon steel as used in these tests and of which superheaters are made.

Since velocity of steam is an important factor in governing the metal temperature such observations indicate the probability of a very definite relation between velocity of steam and oxidation of metal through dissociation of steam.

ELECTROLYTIC CELLS IN CHLORINATION FOR THE DESTRUCTION OF ALGAE[1]

By William T. Bailey[2]

At the last meeting of the Iowa section of the American Water Works Association in Council Bluffs, a paper was read on this subject by Dr. Joseph B. Thornell, who was chemist for the Council Bluffs City Water Works at that time. Dr. Thornell's paper was not published because he felt that insufficient data had been collected in the short time in which he had had to conduct the work. Therefore this paper is in part a repetition of the one given by Dr. Thornell.

Houston was the first to notice the value of chlorine as an algicide, during the treatment of the Lincoln, England, water supply in 1908. Hale first used it for the destruction of algae in America. This was in connection with the elimination of tastes and odors from the New York water supply in the year 1921. It has been used at Davenport, Iowa, Omaha, Nebraska, Kansas City, Kansas, and at other plants, with very good results.

The Council Bluffs City Water Works depends entirely upon coagulation and sedimentation for clarifying its water supply. This method of clarifying Missouri river water requires a very large settling basin area in proportion to the amount of water pumped. Since the water is necessarily held from 4 to 7 days in open basins after it has become relatively clear, an ideal condition for the growth of aquatic microörganisms is produced.

Previous to 1926, these algal growths were destroyed by the periodic dosing with copper sulphate, which is a very effective agent for killing algae, but its intermittent use was found very unsatisfactory because the growths would no sooner be checked in one place than they would be flourishing in another. Consequently, the water carried an odor mildly suggestive of "fish in a pig pen" most of the time during the warm summer months. This odor was at least partly caused by dead algae decaying on the walls of the basins or

[1] Presented before the Missouri Valley Section meeting, October 4, 1928.
[2] Water Department, Council Bluffs, Ia.

floating freely in the water, and also partly due to the myriads of microscopic animals which fed upon the plant forms. Some of these animals, such as Cyclops and aquatic earth worms are large enough to be seen with the naked eye, and, although considered of no sanitary importance in themselves, would cause considerable complaint from water consumers should they become so numerous as to get into the mains. Bacteria also increased enormously in the unchlorinated water because of the presence of this decaying organic matter. Although the odor contributed to drinking water by algae is very undesirable, the unsightliness of a grayish-brown mass of decaying algae is just as undesirable. Either will produce a very unfavorable psychological effect on persons visiting the plant.

CHLORINE AS AN ALGICIDE

Realizing that the most rational treatment would be to destroy the algae, if possible, as they enter the basins so as to give them no chance to live and multiply there, Dr. Thornell conducted a test of the use of liquid chlorine at the river plant coagulant house in the summer of 1926. He found that the use of from 0.8 to 1.0 p.p.m. chlorine would almost completely stop the growth of algae on the settling basins and greatly inhibit their growth on the clear water basins. The chlorine also caused the old growths to loosen from the walls of all the basins.

After due investigation it was decided that the electrolytic cells were preferable to the use of liquid chlorine, inasmuch as users of these cells claimed greater bacterial efficiency, cheaper chlorine, easy operation, and reliability of the cells. Also the storing of a car of salt seemed an easier matter than handling chlorine cylinders.

These cells were put in operation in the fall of 1926, and were used during the summer of 1927 by Dr. Thornell, with very good results so far as the prevention of algae growths was concerned. Dr. Thornell says that some of the blue-green algae, such as Microcystis, persisted as thin plaster like bands on some of the vertical walls at the river plant, and that some of the short, bright green filaments were able to cling to the walls of the two smallest basins where strong vertical currents were produced by the water entering the reservoir. This he attributed to the free exchange of carbon dioxide and oxygen making these points particularly favorable to the growths of these algae. However, the long filamentous green or yellow green growths, which were previously found on the sloping

walls, were absent. The free floating forms such as diatoms seemed to be absent also.

A bright green filamentous form, Stigecolonium, made its appearance in the clear water basins in February, 1928, before the basins were entirely free from ice. But none of the blue greens or diatoms, which are much more apt to produce odors than is Stigecolonium, appeared before the last of April. Since the temperature of the water was about 50°F., we waited until the temperature was above 60°F., before starting the chlorine cells because of danger of producing chlorine tastes in the colder water. In the meantime copper sulphate was used at intervals to keep down the algae. The cells when started were set to produce 0.5 p.p.m. chlorine, and this was gradually increased to 1.0. Within 3 or 4 days after the cells were put in operation, the growths on the wall of the river basins, which consisted mainly of Oscillatoria accompanied by diatoms and protozoa, began to loosen up and float on the surface where they could be removed by skimming. Shortly afterwards the growths of Stigecolonium at the clear water basins came loose, except a small amount near the pipes where very strong currents were produced by water entering the basins. Such growths persisted at these points all summer. So long as the chlorine treatment was from 0.8 to 1.0 p.p.m., and the cells apparently producing the required chlorine, the only growths noticed were the small patches of Microcystis and Stigecolonium (presumably) observed by Dr. Thornell the preceding summer, and small amounts of Oscillatoria and diatoms.

DIFFICULTY OF DETERMINING AMOUNT OF ELECTROLYTIC CHLORINE

At times we experienced some difficulty in determining the exact amount of chlorine added to the water from the cells. In this type of equipment the amount of chlorine produced is determined by the amperes of current passing through the salt solution within the cells. The bottom of these cells consists of asbestos paper diaphragms which must be changed at intervals of about four weeks. As the time for changing the diaphragms approaches we notice a slight increase in the voltage required to pass the necessary amperage through the cells. At the same time the chlorine production apparently falls below the theoretical figure. Since the turbidity of the water being treated is from 200 to 900 p.p.m., we are unable to determine the residual chlorine by the orthotolidin method. Therefore, our only check on the amount of chlorine produced is by observing

an enormous increase in the bacterial count of the settled water, and the appearance of blue green algae on the walls of the settling basins. We find that on renewing the diaphragms the voltage drops and the cells regain their efficiency. The bacterial count of the settled water is again normal, and the algal growths break loose and float on the surface where they are removed.

When the chlorine treatment was 0.6 p.p.m., or less, there was considerable growth of algae on the settling basins, but very little on the clear water basins. Microscopic examination of these growths showed that the Oscillatoria, which were predominant, were practically motionless, while they have a rather vigorous movement when growing normally, from which they get their name. With the Oscillatoria were many diatoms, chiefly Navicula, protozoa of the ciliate, flagellate, and ameboid types, many Cyclops, a few nematodes, and quite a few aquatic earth worms. At other points along the reservoir walls fairly luxurious growths of Cosmarium, accompanied by the diatoms and protozoa, were found. But at no time have there been enough algae to produce tastes or odors in the water. Neither have there been any chlorine tastes. In order to prevent chlorine tastes, we regulate our final chlorination of the water to such a rate that the water entering the mains shows a residual chlorine content of from 0.06 to 0.2 p.p.m. after standing 10 minutes. But we have never found any residual chlorine with the orthotolidin test in any of our basins excepting the one in which the freshly chlorinated water enters.

B. COLI RESULTS

By regulating the final chlorination of water so that the residual chlorine in the water entering the mains is from 0.06 to 0.2 p.p.m., we have kept the positive gas formers to a minimum in the tap water. None of the positive tubes have shown the presence of B. coli during the time we have been using the double chlorine treatment, but as soon as the preliminary chlorination was stopped we found a large increase in the gas formers of the tap water, even when the residual chlorine content was the same as when double treatment was used. This result has also been observed at the Omaha, Nebraska, water works, and may be due to the fact that the total amount of chlorine used, in the double treatment, is much greater than in the single treatment.

COMPARISON OF BACTERICIDAL EFFECTS OF ELECTROLYTIC AND LIQUID CHLORINE

Dr. Thornell conducted a comparative test to find whether or not there was any difference in the bactericidal power of the liquid chlorine and the cell chlorine and obtained results which seemed to indicate that that of the electrolytic cell chlorine was slightly greater. His test was run over a short period of time, and therefore met with considerable criticism. These tests have been repeated this summer

TABLE 1

Comparative test of chlorination of water with liquid chlorine and electrolytic cell chlorine

	Chlorine treatment	Bacteria per cubic centimeter						Gas formers in lactose broth, 48 hours at 37°C.			B. Coli confirmations on eosine methylene blue agar		
		Lactose litmus agar, 24 hours, 37°C.			Nutrient agar, 48 hours, room temperature			Raw water	Cell Cl_2	Liquid Cl_2	Raw water	Cell Cl_2	Liquid Cl_2
		Raw water	Cell Cl_2	Liquid Cl_2	Raw water	Cell Cl_2	Liquid Cl_2	Positive tube, 1 cc.	Positive 10 cc. tubes	Positive 10 cc. tubes	Positive 10 cc. tubes	Positive 10 cc. tubes	Positive 10 cc. tubes
	p.p.m.												
I	1.0	11,400	150	160	24,400	150	170	23/23	54/79	35/79	23/23	7/79	3/79
II	1.0	—	130	210	—	190	240	—	21/40	21/40	—	2/40	3/40
III	0.6	10,100	120	130	32,000	210	230	16/16	46/108	64/108	16/16	23/108	23/108
IV	0.5	1,300	65	65	12,300	125	105	8/8	57/80	54/80	8/8	31/80	21/80

The bacterial counts on the treated water are averages of from 12 to 20 samples. In the gas formations, and B. Coli confirmations, the numerator is the number of positive tubes, while the denominator is the total number of tubes planted in that series.

over a period of about six weeks with each series of samples taken within one or two weeks after changing the asbestos diaphragms in the cells.

The water in leaving the mixing chamber under the coagulant house flows through two pipes of the same size and at the same level into the third settling basin. One of these pipes directs its flow of water eastward and the other turns its flow southward by an elbow on its outer end. Samples were obtained near the outer end of each pipe where the water had not received an opportunity to mix with

the water from the other pipe. In order to check the amount of water flowing through each pipe, several samples were taken when the chlorine from one cell was being discharged into each of these pipes while the discharge from the third cell was added to a solution of ferrous sulfate which was applied at the point where the raw water enters the mixing chamber. Since there is no appreciable difference in the bacterial count and B. coli content I have assumed that approximately equal amounts of water passed through each pipe. The cell chlorine was discharged into one pipe and the liquid chlorine into the other.

Table 1 shows the results obtained from these tests.

The first series of samples were taken while treating each half of the water with one part per million chlorine, but air was mixed with the liquid chlorine by taking it from the Wallace and Tiernan chlorinator with a pyrex injector which exerted quite a strong suction on the hose. There is no appreciable difference in the bacterial counts, but 68 per cent positive tubes were found in the water treated by electrolytic chlorine to 40 per cent in the water treated by liquid chlorine and air. The B. coli confirmations show 8.9 per cent positive tubes for the cell chlorine to 3.7 per cent for the liquid chlorine.

The second series of samples were taken while treating the water with one part per million chlorine, and without mixing air with the liquid chlorine solution. There seems to be a slight difference in the bacterial and B. coli reductions in favor of the cell chlorine and also a difference between Series I and Series II which apparently indicates that a mixture of liquid chlorine and air is more effective than liquid chlorine alone.

The third set of results is from samples taken when the water was being treated with 0.6 p.p.m. chlorine and no air mixed with the liquid chlorine. Again there appears to be a very slightly greater bacterial and B. coli reduction with the cell chlorine, but not enough to be significant.

The last series of samples were taken while treating with 0.5 p.p.m. chlorine. Just before starting on this set, we changed diaphragms in the cells, and added the sodium hydroxide solution formed by the cells to the water which was being treated with the chlorine from the cells. The bacterial count in 24 hours is the same, but there is a slight difference in the 48 hour count in favor of the liquid chlorine. The number of positive gas tubes and B. coli confirmations on eosine methylene blue agar is also slightly in favor of the liquid chlorine,

and is apparently a reversal of the preceding tests. But we believe that all the differences are within the limits of experimental error with random sampling and, therefore, of little consequence.

COMPARISONS OF COSTS

We could hardly conclude from these experiments that electrolytic chlorine was of greater bactericidal value than liquid chlorine. Although its use has been successful in preventing algae tastes and odors, the cost of producing electrolytic cell chlorine at our plant compares very unfavorably with the cost of using liquid chlorine.

ERRORS IN THE CLARK METHOD FOR DETERMINING HARDNESS[1]

By George G. Town

The Clark[2] method for determining the hardness of water has not proved as satisfactory as might be desired on account of the wide difference between the hardness calculated from gravimetric results and that obtained by titration with standard soap solution. The purpose of this investigation was to determine the cause of this difference, and, if possible, to develop a more accurate method.

EXPERIMENTAL

Reagents

Standard calcium solution. Two-tenths of a gram of pure calcium carbonate was dissolved in dilute hydrochloric acid and the excess of acid expelled by evaporating several times to dryness on a water bath. The residue was dissolved in 1 liter of water. The solution of magnesium was prepared in the same manner.

Standard soap solution. One hundred grams of dry castile soap were dissolved in 1 liter of 80 per cent alcohol and allowed to stand several days. Approximately 100 cc. of the above stock solution were diluted to 1 liter and this dilute solution adjusted so that it would give a permanent lather when 6.4 cc. were properly added to 20 cc. of the standard calcium chloride solution which had been diluted to 50 cc. with distilled water.

Method

In both the standardizations and all of the titrations the various amounts of the chlorides were put in 250 cc. glass stoppered bottles, and where the amount taken was less than 50 cc. distilled water was added to make that amount.

Before studying the reaction of the various salts with soap it was necessary to determine whether the shape of the container had any effect on the results and the effect of the rate of adding the soap

[1] From the Department of Chemistry, University of Wisconsin, Extension Division, Milwaukee, Wisconsin.

[2] British Repertory of Patent Inventions, 1841.

solution. The results contained in table 1 show that the shape of the container does not affect the results when the flasks are shaken vigorously up and down, but it is impossible to get concordant results by simply whirling the solutions as in an ordinary titration.

With the calcium solutions the rate of adding the soap solution does not affect the end point. The curves on figure 1[3] show that the rate of adding the soap solution does affect the end point with

TABLE 1

Comparative end points in cubic centimeters of standard soap solution required to give a permanent lather with 20 cc. of standard calcium solution in various shaped vessels

Round glass stoppered 250 cc. bottles			
6.35	6.50	6.30	6.40
6.45	6.45	6.45	6.50
Average 6.40 cc.			
Rubber stoppered 250 cc. Erlenmeyer flasks			
6.45	6.60	6.40	
6.40	6.38	6.30	
Average 6.40 cc.			
Rubber stoppered 250 cc. flat bottom extraction flasks			
6.30	6.25	6.55	
6.50	6.40	6.40	
Average 6.40 cc.			
Rubber stoppered 250 cc. round bottom flasks			
6.45	6.40		
6.45	6.45		
Average 6.44 cc.			
Erlenmeyer flasks whirled back and forth as in ordinary titration			
7.0—7.5—7.4—7.8—8.0—7.6			

magnesium solutions. Curve 1 represents the effect of adding the soap solution rapidly and shows irregularity and low results. Curve 2 shows the correct values as determined by proper addition of soap solution. These curves confirm the observations of G. Magnanini[4] that magnesium solutions react slowly with soaps.

[3] The blank on the distilled water used has been subtracted from all curves. 1.2 cc. soap.

[4] Gazette, 36: I, 369–73, 1906.

Since calcium and magnesium salts are the chief factors causing the hardness of a water, solutions of various concentrations of their chlorides were titrated with standard soap solution and those results are recorded graphically in figure 2. These results disprove the statement of Campbell[5] that equivalent solutions of calcium and magnesium consume the same amount of soap solutions when the hardness is less than five parts per million.

The quantity of soap used by different concentrations of magnesium is not equally proportionate to the amount of magnesium present (fig. 2). It was therefore necessary to determine the effect

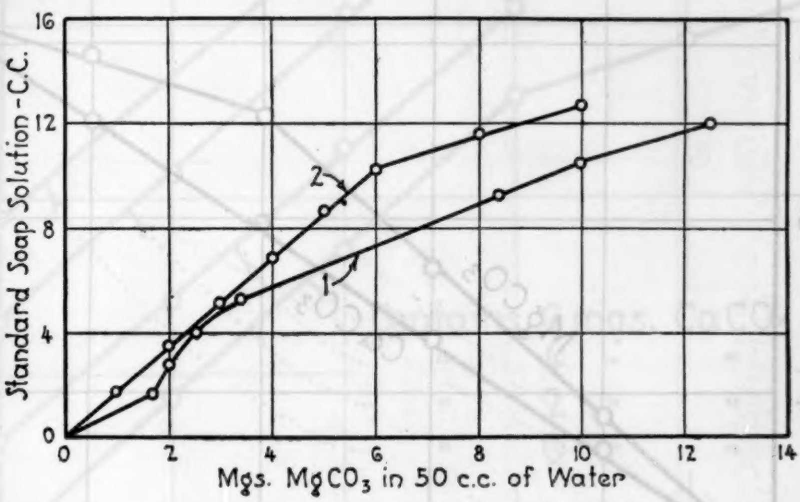

FIG. 1

of the presence of magnesium on the titration of calcium solutions with soap. Figure 3 contains curves drawn from data obtained by titrating the various solutions of magnesium and calcium indicated. The curves are parallel straight lines up to the point that coincides to the concentration at which the break occurs in the magnesium curve. The magnesium curve is given to facilitate comparison. These data show that there is a limiting concentration of magnesium in a water that may be titrated with soap solution. It illustrates graphically one of the reasons why it is necessary to dilute an excessively hard water to obtain concordant results.

[5] Philosophical Magazine, 3: 37, 171, 1850.

Among other things Campbell[5] noticed that, in carefully titrating a water containing both calcium and magnesium, an end point was reached which could be destroyed by further addition of soap solution, and could only be restored by adding considerably more soap solution. Th. Gorside[6] in 1875 also mentions the fact that, with

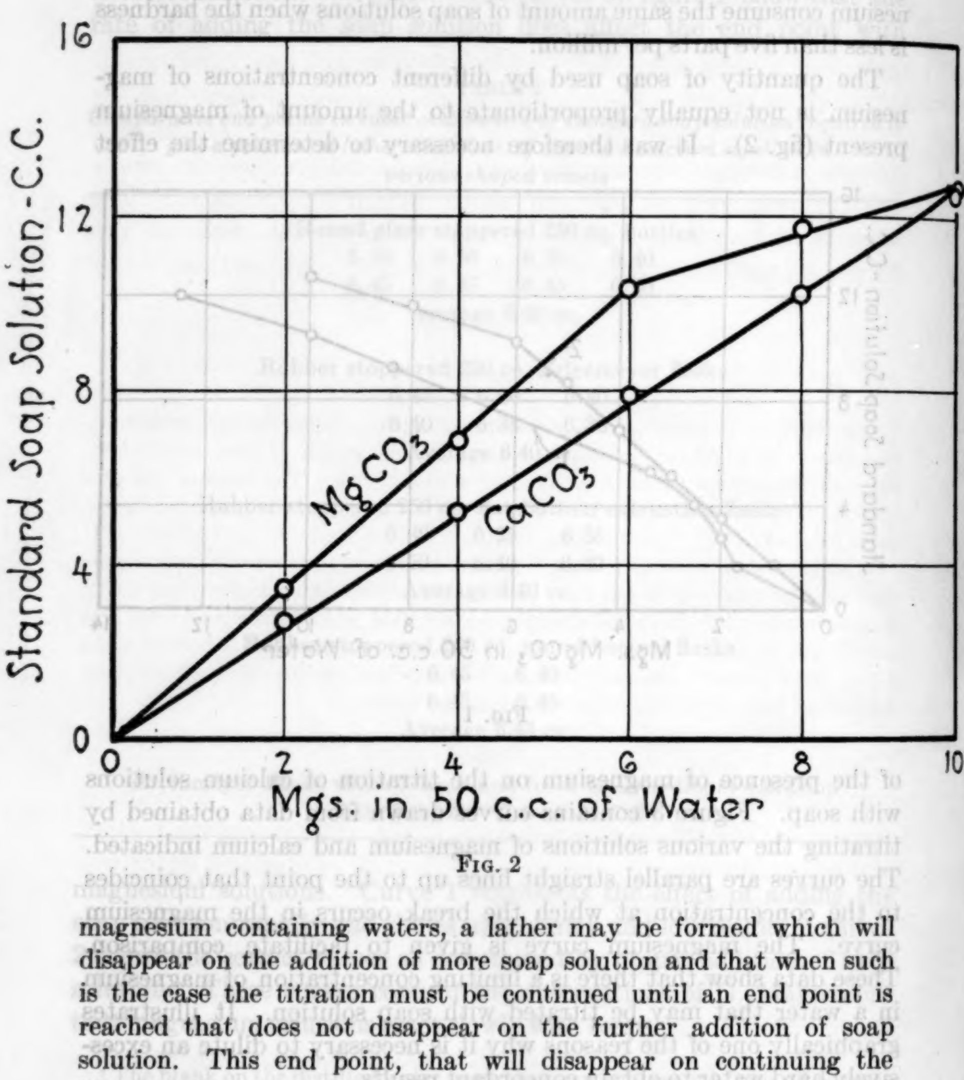

FIG. 2

magnesium containing waters, a lather may be formed which will disappear on the addition of more soap solution and that when such is the case the titration must be continued until an end point is reached that does not disappear on the further addition of soap solution. This end point, that will disappear on continuing the titration, has been termed the "false" end point. The false end

[6] Chem. News, 31: 245, 1875.

point was carefully examined by Gottschalk and Roesler[7] in 1904. They give curves showing that the false end point is quantitative at the point when all the calcium has reacted with soap. In order to verify these results various solutions of calcium and magnesium were titrated with soap solution and the false end point carefully

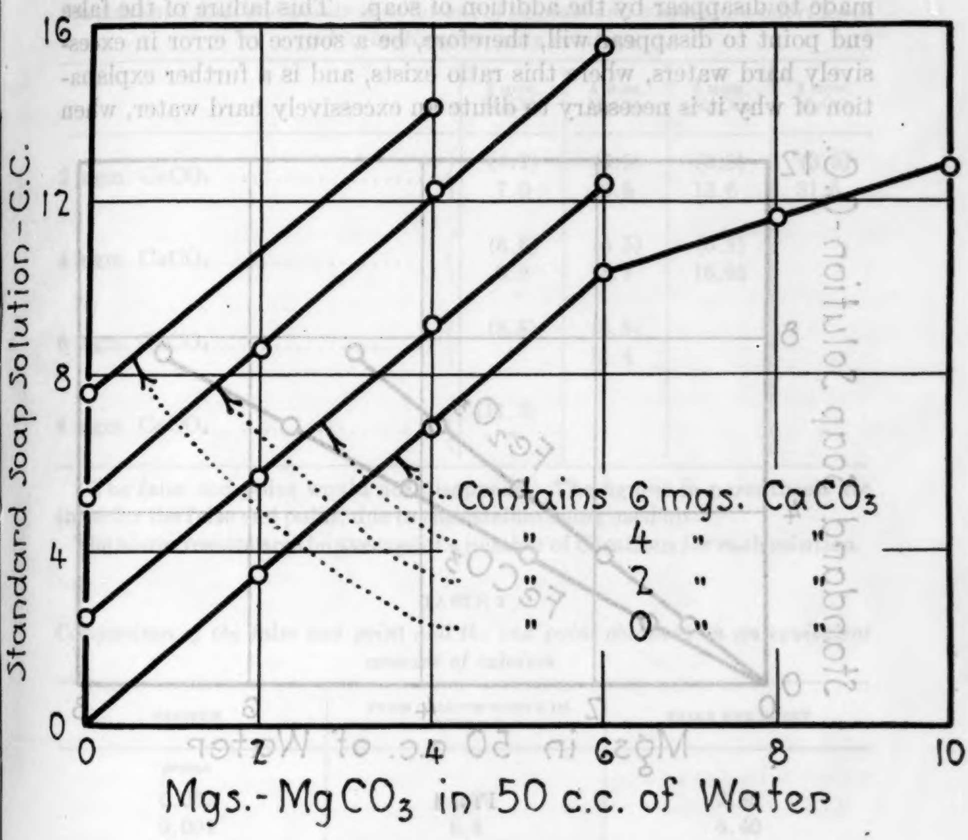

FIG. 3

observed. Tables 2 and 3 were constructed from these data, together with that from the curves on figure 2. The tables show that the false end point, occurring in every careful determination of the hardness of water, is quantitative at the point where the calcium has all reacted with soap, providing there is no iron present. This is in agreement with the results obtained by Gottschalk and Roesler.

[7] J. Am. Chem. Soc., 26: 85, 1904.

The common statement that the false end point will disappear on the further addition of 0.5 cc. of the soap solution is only partially true. When the ratio of calcium to magnesium approaches three to one, and their concentration is 180 parts per million or greater, the first end point obtained is that for the calcium present and cannot be made to disappear by the addition of soap. This failure of the false end point to disappear will, therefore, be a source of error in excessively hard waters, where this ratio exists, and is a further explanation of why it is necessary to dilute an excessively hard water, when

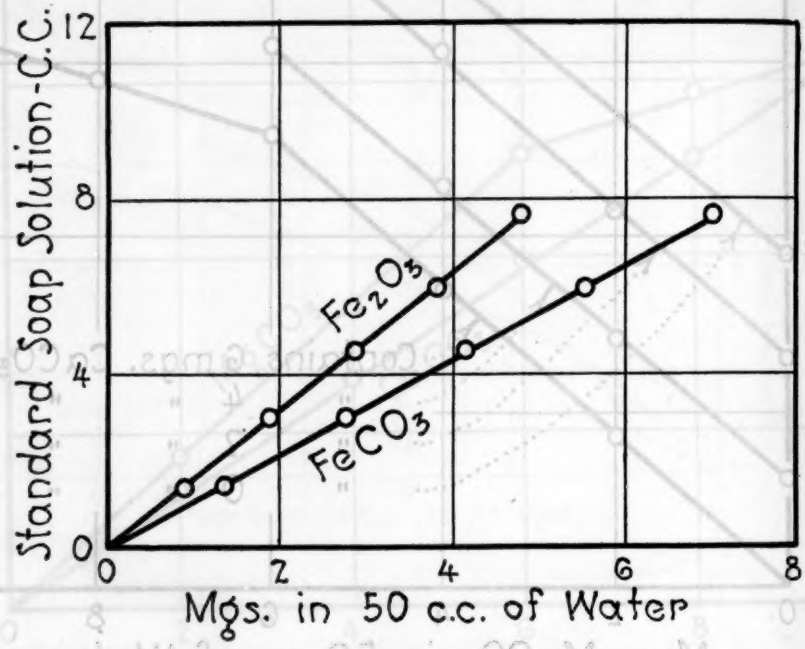

FIG. 4

determining the hardness by the soap method and if necessary to adjust the ratio of calcium and magnesium.

The next most important element affecting the determination of the hardness of water by the soap method is iron. Figure 4 shows the results of titrating ferrous chloride solutions of various concentrations. The results are plotted as milligrams of ferric oxide and ferrous carbonate. From the curves it is evident that the ratio of iron to the soap solution is constant for the solutions titrated.

The results contained in table 4 show that the titration of a solution

of calcium,,iron and magnesium is the sum of the titrations of equivalent amounts of each. The table also shows the effect of iron on the false end point. Although magnesium is more basic than iron, it

TABLE 2

The false and final end points on solutions of calcium and magnesium chlorides in cubic centimeters soap solution

	2 MGM. $MgCO_3$	4 MGM. $MgCO_3$	6 MGM. $MgCO_3$	8 MGM. $MgCO_3$
2 mgm. $CaCO_3$	(4.2) 7.0	(3.9) 10.5	(3.8) 13.6	(3.5) 31.6
4 mgm. $CaCO_3$	(6.6) 9.9	(6.5) 13.7	(6.5) 16.95	
6 mgm. $CaCO_3$	(8.8) *	(8.8) 15.4		
8 mgm. $CaCO_3$	(11.2) *			

* The false end point would not disappear. The figures in parenthesis are those for the false end point, due to the calcium being used up.

The above results are the average of a number of titrations for each solution.

TABLE 3

Comparison of the false end point and the end point obtained on an equivalent amount of calcium

CALCIUM	FROM CALCIUM CURVE IN FIGURE 2	FALSE END POINT
grams		
0.002	4.0	3.80
0.004	6.4	6.40
0.006	9.2	8.80
0.008	11.4	11.20

The figures in this table are the average of a number of determinations.

appears that the iron reacts with the soap first, as the false end point is increased by the amount of the iron present.

Changes in barometric pressure or temperature do not affect the results. Titrations were made at pressures as high as 15 pounds above barometric pressure (73.8 cm.) and in evacuated flasks where

the absolute pressure was equivalent to 6 mm. of mercury. The results in both cases were the same as when titrating at ordinary atmospheric pressures.

PROPOSED METHOD

The present method of conducting the Clark method for the determination of the hardness of water will not give accurate results for the following reasons:

1. The hardness is considered as due entirely to calcium, when converting cubic centimeters of soap solution used in a titration to

TABLE 4

$MgCO_3$	Fe_2O_3	$CaCO_3$	FALSE END POINT	END POINT ON EQUAL AMOUNTS OF Ca AND Fe ALONE	FINAL END POINT
grams	*grams*	*grams*			
0.002	0.001	0.002	5.6	5.6	9.15
0.002	0.001	0.004	8.0	8.0	11.65
0.004	0.001	0.004	7.9	8.0	15.40
0.006	0.001	0.002	5.8	5.6	14.70

$CaCO_3$	END POINT IN CUBIC CENTIMETER OF STANDARD SOAP SOLUTION
grams	*cc.*
0.002	4.0
0.004	6.4

parts per million of calcium carbonate. This is a source of error, as is shown by figure 2.

2. The error due to the soap consumed by the iron is not considered.

3. The blank on distilled water equivalent to the amount of water in the sample is not considered.

These three sources of error are eliminated by the following method:

Curves of hardness of the standard magnesium, calcium and iron solutions are prepared by titrating various amounts of the standard solutions with the standard soap solution. In plotting these results the blank on the distilled water used should first be substracted.

In all titrations to prepare the curves for the hardness of the standard waters, the determinations should be made on 50 cc., and

where the quantity of standard solution is less than 50 cc., sufficient distilled water is added to make that amount.

Fifty cubic centimeters[8] of the unknown water are pipetted into a 250 cc. glass stoppered bottle. The standard soap solution is slowly added from a burette (0.2 cc. at a time), shaking after each addition, until the false end point is reached and noted. The titration is continued slowly with shaking until a lather is formed that will last five minutes. This is the final end point.

The number of cubic centimeters required to complete the titration beyond the false end point are consumed by the magnesium present, and the amount of magnesium is obtained by consulting the curve on figure 2. The cubic centimeters of soap solution necessary to produce the false end point are consumed by the blank on distilled water, together with the calcium and the iron present. From a gravimetric or colorimetric determination of the iron and the curves on figure 4 the cubic centimeters of soap used by the iron are estimated. This amount plus the blank on distilled water (1.2 cc.) subtracted from the false end point gives the cubic centimeters of soap consumed by the calcium. From the curve on figure 2 the amount of $CaCO_3$ is estimated.

By this corrected method the hardness of a water may be accurately reported in parts per million of calcium, magnesium and iron as carbonates.

The following analysis of a water will show the accuracy of the method:

Gravimetric results on 500 cc. of the water

	grams	*grams*	*grams*
Fe_2O_3	0.0012	0.0015	0.0018
$CaCO_3$	0.0901	0.00909	0.0920
$MgCO_3$	0.0755	0.07500	

Results of soap titration on 20 cc. of the water diluted to 50 cc. with distilled water

	cc. of standard soap solution
False end point	5.7
False end point	11.8

[8] If the water consumes more than 15 cc. of the standard soap solution it is necessary to use a smaller quantity of water and dilute to 50 cc. with distilled water.

	cc. of standard soap solution
Soap consumed by Fe	0.1[9]
Blank on water	1.2
Total	1.3

False end point	5.7
Soap used by blank Fe	1.3
Soap consumed by Ca	4.4

4.4 cc. soap—0.0034 gram $CaCO_3$ (curve on figure 2)

Final end point	11.8
False end point	5.7
Soap consumed by Mg	6.1

6.1 cc. soap—0.0035 gram $MgCO_3$ (curve on figure 2)

Hardness of the water in parts per million

	By new method	By old Clark method	Gravimetrically
Fe_2O_3	3		3
$CaCO_3$	170		182
$MgCO_3$	175		151
Total	348	415	336

CONCLUSIONS

1. The Clark method for determining the hardness of water is inaccurate for the following reasons:

a. The magnesium and iron present are considered as having the same soap consuming power as the calcium.

b. The blank on distilled water equivalent to the amount of water in the sample is not considered.

2. The proposed method is more accurate because:

a. It has been shown that the magnesium and iron present do not have the same soap consuming power as the calcium and from the standard curves proper values may be assigned to each.

b. Allowance is made for the blank on distilled water equivalent to the amount of water in the sample.

3. The results are not affected by variation in barometric pressure or changes in temperature.

[9] Curve on figure 4.

MANHOLE FRAMES AND COVERS[1]

As representative of the American Water Works Association, on the American Standards Association Sectional Committee on Manhole Frames and Covers (A-35) I submit the following progress report:

The subcommittee of which I was a member has made its report to the Sectional Committee on the subject of Manhole Frames and Covers for sewer, gas, water, steam and air systems. The Correlating Committee is now at work bringing together the various designs submitted by the several subcommittees, preparing drawings and specifications and arranging the material for presentation to the manufacturers and users of manhole frames and covers. It is expected that the Division of Simplified Practice, of the Department of Commerce, will publish this information in tentative form and that before long all parties interested will have an opportunity to go over the proposed designs and specifications.

Of necessity all this work has taken considerable time, but it is believed that the work is being well done and will result in standards that will be of benefit not only to the water works fraternity, but to all others who have occasion to use such materials.

Respectfully submitted,

FRANK A. MARSTON,
Representative.

[1] Report presented at the Toronto Convention, June 25, 1929.

ZINC COATING OF IRON AND STEEL[1]

As a representative of the American Water Works Association on the Sectional Committee on Specifications for Zinc Coating of Iron and Steel, serving by appointment on Technical Committee IV—Pipes, Conduits and Their Fittings, I have the following report and comments to make:

The personnel of Committee IV as listed and as fairly well attending the first meeting, represented the following groups: Producers, 6; of general interest, 2; consumers, 11. Inclusion of the water works interest on Committee IV was probably due to the title—Pipes, Conduits and Their Fittings, only a small division of which, as to the nature of the material and class of coatings, is of interest to water works engineers. However, as a member of Sub-committee C, assigned to hot-dip processes, and due to the fact that the work of all of the committees interlocked, your representative was in touch with the field as a whole.

In the beginning of the Sectional Committee's work, sub-committees were established as follows:

I. Technical Committee I—Hardware and Fastenings
II. Sheets and Sheet Products
III. Plates, Bars, Structural Shapes and Their Products
IV. Pipes, Conduits and Their Fittings
V. Wire and Wire Products
VI. Marine Hardware and Ship Fittings. (Organization deferred)
VII. Methods of Testing

Committee I—Hardware and Fastenings—has been reorganized and has mapped out a program which it is hoped will lead to progress.

Committee II—Sheets and Sheet Products—has submitted proposed specifications which were accepted for publication without, however, being adopted by the sponsor. This class has been covered by Serial Designation A-93-27 of the A. S. T. M. under the jurisdiction of the A. S. T. M. Committee A-5 on Corrosion of Iron and Steel.

Committee III—Structural Steel Shapes, Plates, Bars and Their Products. Specifications, Serial Designation A-123-28-T, have been

[1] Report presented at the Toronto Convention, June 25, 1929.

submitted and accepted by the sponsor body and appear in the 1928 book of Tentative Standards of the A. S. T. M. Further amendments have been proposed.

It is felt that the work of this Committee and the material represented is of especial interest to water works engineers, a great deal of whose work is of a jobbing nature and the engineer in charge should know something of the processes and means of making tests and assuring himself that he gets what he specifies.

Committee IV—Pipes, Conduits and Their Fittings. Specifications have been prepared and are still awaiting further comment or alteration. This group includes hot-dipped pipe suitable for water works and conduits galvanized by other processes and mostly used for electrical conduits. Your representative considers that it is unfortunate that both classes were considered in the same group as it may lead to confusion and the offering of and acceptance of a class of pipe bearing the general name "galvanized" which will prove unsuitable for the material as used by water works engineers.

Committees V, VI and VII. These committees report progress.

It has been proposed that the Sectional Committee on Specifications for Zinc Coating of Iron and Steel be disbanded as such and the work be transferred to or carried on, with essentially the same personnel, by corresponding committees of the sponsor body.

There are now published a number of standards and tentative standards which cover the subject of galvanized materials of use in the water works field. As the requirements in this field for galvanized articles are of an occasional or jobbing nature, the water works engineer often is at a loss as to what to specify and how to test galvanized material, and it is with this in mind that your representative has urged the inclusion in specifications of some information as to processes, terminology and tests which will serve as guides and be of assistance to the occasional buyer, particularly of stock material in the competitive field. Competition in the stock material field has led to the offering of so-called galvanized products, which has served to lower the regard in which real galvanized articles should be held. If the consumer knows his processes and tests, and insists upon them and is willing to pay the very slight increase in cost, the galvanized material trade will be the first to meet such requirements.

Respectfully submitted,

Ray C. Ewry,
Representative.

SOCIETY AFFAIRS

THE MINNESOTA SECTION

A joint meeting between the Minnesota Section and the League of Minnesota Municipalities was held Thursday afternoon, June 13, 1929. Papers read from the Water Works Section were as follows: C. P. Holmes of the Western Actuarial Bureau, Chicago, Ill. on "Fire Insurance Rates." Carl Zapfe, President Water and Light Board, Brainerd, Minn. did not read his paper on "The Elimination of Manganese from Water" due to the limited time which he had.

On Friday, June 14, C. F. Keyes, President of Board of Estimate and Taxation, Minneapolis, read a paper before the League on "Stream Pollution."

The meeting of the Minnesota Section was called to order in the Austin High School, Austin, Minn. at 9:30 a.m. by Charles Foster, Vice-Chairman. Mr. Foster presided in the absence of J. W. Kelsey, who was unable to attend the session.

The minutes of the previous meeting were read and approved. The treasurer's report was read and approved.

Arthur S. Milinowski read a paper on "Some Financial Aspects of Water and Sewerage Systems." After reading his paper Mr. Milinowski opened the round table discussion on the subject which was entered into by Mr. Crowley of St. Paul, Mr. Cochrane, guest, from Watertown, S. D.

Mr. M. C. Bright of Buhl, Minn. presented a paper on "How Meters Reduce Water Consumption." This paper was of much interest to the members present and was well delivered. After the paper was read it was discussed by Messrs. Crowley, Druar, and Forsberg.

Mr. A. C. Janzig of the Minneapolis Filtration Plant read a paper prepared by himself and I. A. Montank, also of Minneapolis, on "The Resolution of Manganese from the Sand of Idle Filters."[1]

Mr. Forsberg reported that the committee which was appointed last year to investigate the joining of the Minnesota Section with the Iowa and Wisconsin sections had nothing new to report on this

[1] This Journal, page 1319.

subject. Again there was some discussion on this by Messrs. Seligman, Foster, Crowley, and Druar. Mr. Forsberg made a motion that the Minnesota Section take definite steps to join with either Iowa and Wisconsin or the Missouri Valley Section, consisting of Iowa, Missouri, Nebraska, and South Dakota. This motion was seconded by Mr. Druar. Mr. Seligman then made an amendment to this motion that the officers of the Minnesota Section be given full power to carry out Mr. Forsberg's motion. This was seconded by Mr. Thompson. The motion and amendment were carried.

After Mr. Forsberg's motion a brief business session was held at which time a report of the Nominating Committee was read and on motion was dully accepted. The Nominating Committee presented the following names for the approval of the section: Charles Foster, of Duluth,—Chairman; M. J. Howe, of Lake City,—Vice-Chairman; L. N. Thompson, of St. Paul, to fill the unexpired term of D. A. Reed of Duluth; J. F. Druar, of St. Paul,—Trustee for three years; R. M. Finch, of Minneapolis,—Secretary. It was regularly moved and seconded that the secretary be instructed to cast a unanimous ballot for these five. Motion was carried. Mr. Foster instructed the secretary to write a letter of condolence to Mr. Reed's family at Duluth.

Mr. Druar then brought up the question of obtaining new members. Quite a discussion followed by Messrs. Forsberg, Crowley, and Seligman.

Mr. Foster, in the absence of Mr. Kelsey, thanked all the men who gave papers for their work in presenting them. There being no further business the meeting adjourned at 11:30 a.m.

ALLEN D. JAMES,
Secretary.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The Contact Surface of Fresh and Salt Water under the Ground near a Sandy Seashore. T. NOMITSU, Y. TOYOHARA, and R. KAMIMOTO. Memoirs Kyoto Imperial Univ., College of Science, Series A, 10: 7, 279–302, September, 1927. The well known theory of HERZBERG has shown the general shape of the contact between fresh water and salt water in formations near the sea coasts; but, to apply it, observations are needed on the ground-water level at many points. The authors formulate equations by which the curve of the boundary between fresh and salt water may be determined if water level is known at only two points. The curve, approximately a parabola, can be constructed from the following data: the densities of the two kinds of water, the fresh water level at a fixed point landward from the shore line, and a "soil constant," which is an index of the permeability of the sand. In experiments in sand-filled boxes, the observed contacts between fresh and salt water agreed very closely with the theoretical curves computed according to the formulae. The effect of diffusion in the experiments was determined to be relatively slight, the salt water boundary shifting only 12.1 cm. (4.8 inches) in 24 days when the initial density of the salt water was 1.032.—*David G. Thompson.*

The Ground-water Resources of Mississippi. L. W. STEPHENSON, W. N. LOGAN, and G. A. WARING. U. S. Geol. Survey, Water-Supply Paper, **576:** 515 pp. 1928. Describes physiography and general geology of the State. There are several good water-bearing horizons. Wells range greatly in depth, many being more than 1,000 feet deep. Water table is usually less than 100 feet below the surface. Artesian water is present in many parts of the State and flowing wells are obtained in the northwest part of the State and in many of the larger valleys. Small springs are common. In general, the waters are soft and of moderate mineral content, though water from Recent alluvium is hard and of moderately high mineral content. A detailed description by counties is given.—(*From abstract by R. M. Leggette*) *David G. Thompson.*

Analyses of Waters of the Salt Creek Field Applied to Underground Problems. Amer. Inst. Min. and Met. Engrs., Tech. Pub. **157:** 17 pp., illus. December,

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

1928. Gives average analyses of eight water horizons from Salt Creek field, Wyoming, and describes correlations based upon chemical character of waters. Use of analyses for identifying "edge" water and locating casing leakage are discussed.—*(From abstract by W. D. Johnston, Jr.) David G. Thompson.*

Das Thermalgebiet von Baden (Hot Springs District of Baden). Lukas Waagen. Intern. Zeitschr. Bohrtech., 36: 20, 175–177, October 15, 1928. A condensed though broad general description of the thermal springs of the Vienna basin, against a background of the regional geologic history. Typical springs are described.—*(From abstract by A. M. Piper) David G. Thompson.*

Wells and Springs of Somerset. Linsdall Richardson, F. G. S. Geological Survey Memoirs, England, 220 pp. 1928. Water supplies, both private and public, in Somerset are obtained in large part from springs and wells. Important aquifers occur in limestone, sandstone, and sand in a dozen formations ranging in age from Upper Devonian to Upper Cretaceous. The report includes many sanitary water analyses, a bibliography of the Bath thermal waters, and logs of numerous deep wells and exploratory borings.—*(From abstract by W. N. White) David G. Thompson.*

Ground Water Suppplies of the Atlantic City Region. David G. Thompson. New Jersey Dept. Conservation and Development, Bulletin 30: 138 pp. 23 figs., 7 pls. 1928. A study of the quantity of water that can be obtained from wells 100 to 200 feet deep on the mainland near Atlantic City, N. J., drawing from the Cohansey formation (Tertiary), and from wells 675 to 850 feet deep on the mainland and beaches drawing from the so-called 800-foot sand of the Kirkwood formation (Tertiary). The principal method of study has been to compare fluctuations of the water level in wells with changes in the rate of pumping. Observations show daily fluctuations of several feet in the hydrostatic head on the 800-foot sand, due to pumping and the effect of ocean tides. When these are eliminated from the water level curves a seasonal fluctuation is found which corresponds to changes in the rate of pumping; the water falling as pumping increases and vice versa. Since about 1893, the head has decreased as much as 100 feet. It is concluded that an increase of 10 million gallons a day in the pumping rate will cause the head to drop to a depth of about 200 feet below the surface in Atlantic City. Similar observations show that the shallow horizons on the mainland have a much higher permeability than the 800-foot sand and a considerable additional quantity of water may be obtained from them without any great loss of head. The proximity of the wells to the ocean creates a danger of contamination of the formations by salt water. Several wells have already been contaminated and abandoned, but the salt water came from leaks in the casing near the surface and the water in the formation is still fresh. However, from a consideration of the relations between fresh and salt water it is concluded that heavy pumping may eventually draw in salt water.—*David G. Thompson.*

Ground Water in the New Haven Area, Connecticut. J. S. Brown. U. S. Geol. Survey, Water-Supply Paper 540: 206 pp. 1928. Describes the general

geology and water supply of an area of 488 square miles surrounding the city of New Haven, with detailed descriptions of the geology and water supply for each township as well as suggestions for future development. Ground water of the region is moderately low in mineral content, though rather hard but in general, satisfactory for ordinary domestic purposes.—(*From abstract by R. M. Leggette*) *David G. Thompson.*

Ground Water Investigation of the Roswell Artesian Basin, New Mexico. Albert G. Fiedler and S. Spencer Nye. Eighth Biennial Rept., New Mexico State Engineer, pp. 83–107. 1928. A preliminary report giving brief descriptions of the general features, geology, and ground-water conditions of the Roswell area, and a general discussion of the development and head of the artesian water, the area of artesian flow, the quantity of water discharged by the wells, and the recharge of the artesian basin. Most of the artesian water is obtained from cavernous limestone and solution channels irregularly distributed in the upper part of a thick series of Permian limestone beds. In 1927 the artesian head from the original level was about 32 feet in the north end of the basin and about 204 feet in the south end. The area of artesian flow has decreased about 238 square miles. Concludes that present draft is somewhat in excess of recharge and recommends that further draft upon the artesian reservoir be prevented.—(*From abstract by S. Spencer Nye*) *David G. Thompson.*

Wells and Springs of Warwickshire. Linsdall Richardson. Memoirs, Geol. Survey of England, 200 pp. 1928 The report gives logs of a large number of deep well and coal exploratory borings and numerous water analyses and describes water supplies, both surface and underground, of Birmingham, Coventry, Warwick, Stratford-on-Avon, Royal Leamington Spa, Nuneaton, and Sutton Coldfield and of 18 urban and rural districts.—(*From abstract by W. N. White*) *David G. Thompson.*

Effect of Earthquakes on Artesian Waters. Stephen Taber. Econ. Geology, 23: 6, 696–697, September–October, 1928. Cites increase in flow and pressure in artesian wells after earthquakes as evidence of compressibility of artesian aquifers.—(*From abstract by S. Spencer Nye*) *David G. Thompson*

Bodenbelastung und Grundwasserstand. Hans Scupin. Hallescher Verband, Jahrb., N. F., 7: 138–144, 1928. This paper describes a field test of the principles that a water-bearing bed is compressible and that a piezometric surface should rise beneath a heavily loaded area. The specific problem is the adjudication of a lawsuit in which it is argued that a railroad fill 43 meters (140 feet) high has caused a rise of the water level. From the results of test borings it is argued that the ground water condition of the locality is artesian and that the rise of the water table is due to upward leakage into a slightly permeable phase of the confining bed. The general conclusion is drawn that compression of a water-bearing bed and consequent rise of the piezometric surface is not possible unless the rock particles are crushed or packed more closely together; that the load required to produce an appreciable effect in

even the most compressible of rocks is far more than that of a fill 43 meters high; and that the effect of loading disappears in time as a new state of equilibrium is attained. (See: KEILHACK, K., p. 257).—*(From abstract by Arthur M. Piper) David G. Thompson.*

Compressibility and Elasticity of Artesian Aquifers. O. E. MEINZER. Econ. Geology, 23, 13, 263–291, May, 1928. The pore space in an artesian aquifer is filled with water that exerts a hydrostatic force against the weight of the overlying rocks. When wells are drilled this force is reduced. It has generally been assumed that artesian aquifers are incompressible and inelastic, but evidence is presented to show that the artesian water, especially in strata of sand and soft sandstone, supports a part of the load of the overlying rocks and that the aquifers contract when the artesian pressure is decreased and expand when it is increased. Compressibility is indicated by laboratory tests, subsidence of the surface, excess of discharge over recharge, lag in the decline in head, local character of changes in hydraulic gradient, tides in wells caused by ocean tides, and fluctuations in head produced by railroad trains. Expansion is indicated chiefly by slow recovery of head after a flowing well is closed. Other possible causes of the phenomena cited as evidences of compressibility and elasticity are rejected as inadequate. These are as follows: (1) expansion and contraction of the water itself; (2) precipitation of solids out of solution in the water; (3) escape of gases out of solution; (4) removal of sand, silt, and clay with the water; (5) leakage through well casings or up through the holes on the outside of the casings, and (6) leakage through the confining beds. Rough computations indicate only very moderate amounts of contraction and expansion but enough to affect radically the conclusions in regard to the recharge, movement, and discharge of the water in the artesian aquifers.—*(From abstract by O. E. Meinzer) David G. Thompson.*

Determination of the Maximal Molecular Water Capacity of the Soil by Means of Centrifuging and Characteristics of Mechanical Properties of Soil by Determining the Maximal Molecular Water Capacity. A. F. LEBEDEFF. Rostov Don. Russia. (Separate, pp. 46–69, of the Russian publication, Pedology.) 20 pp. 1928. This paper, published in English, is based on about 10 months of work done recently by Professor LEBEDEFF, in the laboratories of the United States Bureau of Soils with a specially constructed centrifuge that gives a maximum force of 70,000 times gravity. The results are of interest to groundwater hydrologists. He distinguishes four kinds of soil moisture; vapor, hygroscopical water, pellicule water, and gravitation water. The pellicule water is "detained by the soil particles by molecular cohesive force. When this force is completely saturated, the soil is in a state of moisture, which I denominate as 'maximal molecular water capacity of soil.' The pellicule water moves in a soil of uniform properties as a liquid, from moister places (with a thicker pellicule) to places with smaller moisture (with a thinner pellicule). Gravity has no influence on the speed of this motion. Hydrostatic pressure does not develop in pellicule water." It was found that generally all "gravitation water" is removed by a force 18,000 times gravity in 1 or 2 minutes. The slight losses of moisture produced by longer centrifuging are attributed to

evaporation. Experiments on 19 samples showed that the moisture equivalent (moisture left after centrifuging at 1,000 times gravity) ranges from 1.04 to 2.67 times the "maximal molecular water capacity." LEBEDEFF wishes next to investigate correlations between the maximal molecular water capacity and other properties of soil. It is sincerely to be hoped that he will be able to carry out these investigations and thereby establish a relation between his maximal molecular water capacity and "specific retention," the determination of which is at present one of the most serious problems in ground-water hydrology.—*(From abstract by O. E. Meinzer) David G. Thompson.*

Borehole Water Supplies in the Union of South Africa. ALEX L. DUTOIT. Reprinted from Transactions of Minutes of Proc. South African Soc. Civil Engrs., Bon Accord Press, Cape Town. 1928. Part I discusses principles of ground-water infiltration and storage and the difficulties inherent in boring and completing successful wells, and gives a brief description of South African artesian areas and a forecast of future well boring in the Union. Part II discusses the water bearing qualities of the most important and widespread geological formations, Part III presents a tabulation of about 8,500 bore holes, subdividing them according to the number bored in each class of rocks, giving percentage of failures, age recorded in boring, yield in gallons per day, and other data. The percentage of failures and the average yield of the successful wells in a given formation are shown to vary within very wide limits in different parts of the Union.—*(From abstract by W. N. White) David G. Thompson.*

Vulgarizaciones hidrogeologicas (Common Features of Hydrology). PABLO FABREGA. Rev. Minera, Madrid, 79: 553–555, 565–566, 577–578, December 1, 8, 16, 1928. A brief general description of three possible cycles ("direct," "reverse," and "magmatic") of the derivation of ground water from, and its return to, the sea; types and examples of springs resulting from each cycle; and factors influencing the movement of ground water.—*(From abstract by S. Spencer Nye) David G. Thompson.*

The New Waterworks for Bilston, England. R. C. S. WALTERS. Water and Water Engineering, 30: 351, 101–105, March 20, 1928. One thousand gallons a day was supplied from two wells 170 feet deep in close-grained sandstone, the working level of the water being 112 feet below the surface. After a boring 500 feet deep was sunk from the bottom of one of the wells into underlying pebble beds, the drawdown was decreased 50 feet and the quantity of water raised per ton of coal was increased 12½ per cent.—*(From abstract by W. N. White) David G. Thompson.*

Abridged Report for 1927 (Rijksbureau voor Drinkwatervoorziening, Beknopt Verslag 1927. (Dutch) Government Department for the Supply of Drinking Water. Review in Public Health Reports, p. 151, July, 1928. Water and Water Engineering, 30: 358, 489. Report of progress in some 100 water supply installations given. Includes a discussion of legislation, goiter research, biological and chemical work, geology, and other subjects.—*(From abstract by W. N. White) David G. Thompson.*

Ausgewählte Kapitel über Grundwasser-verhältnisse des mitteldeutschen Industriebezirks, ihre Beziehungen zu Wasserversorgung und Bergbau. C. Gäbert. Hallescher Verband, Jahrb., N. F., 7: 127–137. 1928. Discusses the general features of the geologic history, water-bearing beds, and quality of the ground water in the Altenburg-Meuselwitzer lignite district and the Querfert-Freyburger basin. The Tertiary rocks of the Altenburg-Meuselwitzer district yield unconfined ground water from beds above the coal and artesian water from beds which underlie the coal. The experience gleaned from mining and mine drainage problems is applied to the development of the artesian water resources.—*(From abstract by Arthur M. Piper) David G. Thompson.*

Die artesischen Quellen der Bahrein-Inseln im Persischen Golf (The Artesian Wells of the Bahrein Islands in the Persian Gulf). Arnold Heim. Eclogae Geol. Helvetiae, 21: 1–6, June, 1928. Rainfall on the islands is an inadequate source of artesian water and the most likely source lies in the mountains of western Arabia, the water following cavernous Tertiary limestones beneath the Dahna Desert to the Bahrein Islands, a distance of 750 miles.—*(From abstract by Arthur M. Piper) David G. Thompson.*

Geologische Bedingungen für die Abgrenzung von Quellschutzbezirken (Geologic Conditions for Delimiting Spring Areas). George Berg. Zeitschr. prakt. Geologie, 36: 8, 124–128, August, 1928. A semi-popular and general treatise on the relation between ground-water circulation and lithologic and structural conditions, especially with regard to protection of springs against inflow of polluted or highly mineralized water and against disturbance of the hydrostatic equilibrium which insures the permanence of the spring. One noteworthy generalization is that the occurrence of thermal and mineral springs along a major fault zone may lead to the false conclusion that the fault plane serves quite generally as a ground-water conduit, whereas the major faults are usually sealed tightly by the products of attrition and ground water circulates in secondary fractures which may be parallel or normal to the main faults. Under such conditions, the areas of influence of springs are limited and erratic in detail of position.—*(From abstract by Arthur M. Piper) David G. Thompson.*

Der Geysir von Herlany (The Geyser at Herlany, Hungary). J. Buchtala. Zeitschr. prakt. Geologie, 36: 9, 149–154. September, 1928. Describes the action of the "geyser" at Herlany, Hungary, actually a drilled well, 404 meters (1,325 feet) deep, and offers a hypothetical explanation. The period of the geyser is about 9 hours. The temperature of the water is 20 to 23°C. (68 to 73°F). The products of eruption contain more carbon dioxide than water. Inasmuch as the temperature is far below the boiling point of water, the usual explanations of geyser action fail. The principle of operation of the geyser is likened to that of an intermittent spring and exemplified by a model which comprises a reservoir and an automatic siphon outlet with discharge at a lower level.—*(From abstract by Arthur M. Piper) David G. Thompson.*

The Origin of Springs and Rivers: an Historical Review. F. D. ADAMS. Fennia, 50: 1, Helsingfors, Finland, 16 pp., with plates. 1928. **Rainfall and Run-off.** F. D. ADAMS. Science, New York, 67: 500–501, 1928. The first paper is an interesting and suggestive contribution, in English, to the history of natural science, by a scientist who has devoted much time to the study of ancient and mediæval writings in the original languages, chiefly Latin, It sketches the history of theories regarding the origin of springs and rivers, beginning with PLATO and ARISTOTLE, primarily for the purpose of determining what causes led the observers of past centuries into error. ARISTOTLE's statement that the rainfall is not sufficient to supply the water carried by the rivers was generally accepted until the 17th century, and was the chief reason why the true origin of rivers remained so long unknown. All the principal interpreters of holy scripture from St. JEROME down and the mediaeval philosophers taught that springs had their origin in the ocean, the water passing into the earth's interior through holes in the sea bottom. They exhausted their ingenuity in trying to account for the motive power which raised these great volumes of water from sea level to the mountain tops and to explain how the salt water became fresh in transit. In 1674 appeared, anonymously, the book "De Origine des Fontaines," which describes the first recorded measurements of rainfall and run-off, from which the conclusion was reached that the water which falls as rain on the basin of the Seine River is six times the volume of the run-off. In the first paper by Professor ADAMS, PAPIN is credited with authorship of the anonymous book, but in the subsequent paper, published in *Science*, the credit is given to PIERRE PERRAULT, of Paris. ANTONIO VALLISNIERI, of Padua, in 1715, published the results of his study of the origin of springs in the Alps, in which he showed that not only springs, but also artesian and other ground waters, are derived from rain and melting snow. His paper is illustrated by six geological sections showing the relation of folded strata to the occurrence of springs, which must represent almost the earliest attempt to depict geological structure in sections. BERNARD PALISSY, 1580, is properly credited with correct views on the subject; MARRIOTTE, co-laborer of PERRAULT, is mentioned, but given less credit than by most historians; there is no mention of VITRUVIUS, architect about the time of Christ, who is commonly credited as the first writer to express a correct view on the subject.—(*From abstract by O. E. Meinzer*) *David G. Thompson.*

La cuenca artesiana del Campo de Cartagena (Artesian Basin of Cartagena, Spain). JOSE MARIÁ RUBIÓ. Rev. Minera, Madrid, 79: 229–231, 433–434, 457–460, May, September, and October, 1928. Describes the artesian basin at Cartagena, province of Murcia, Spain.—(*From abstract by W. D. Johnston, Jr.*) *David G. Thompson.*

Legal Report Proposing a Plan of Water Legislation Reconciling Public Developments and Private Rights, to the Joint Committee of the California Senate and Assembly upon Water Resources. SAMUEL C. WIEL. 81 pp., San Francisco, November 1, 1928. MR. WIEL, in proposing legislation to facilitate adjustment of claims for damage against public utilities developing water resources of the State of California, recognizes the fundamental relation of

ground water to the flow of influent and effluent streams. Eighteen pages, nearly a fourth of the paper, are devoted to these relations as basic principles in the estimation of damage to riparian land holders. It is held that the ground water factor should dominate the estimate for the influent reaches of a stream inasmuch as the ground water conditions constitute a foundation that must be left undisturbed as a prerequisite to every water supply. This unique but sound application of fundamental hydrologic principles to water right equities is most wholesome.—*(From abstract by Arthur M. Piper) David G. Thompson.*

Methods of Lowering the Level of Subsoil Water in Constructional Work Underground. Willy Sichardt. Water and Water Engineering, London, 30: 359, 523–524. November 20, 1928. Describes methods of lowering the level of subsoil water by stages, the method ordinarily employed in underground construction, and discusses the advantage, particularly in the case of underground railway and similar construction, of lowering the water table in one operation by the use of large deep wells equipped with vertical centrifugal pumps located along the line of the proposed excavation.—*(From abstract by W. N. White) David G. Thompson.*

A General View of Recent Progress in Utilizing Ground Waters in Japan. Masakichi Suzuki. 9 pp. 1928 (?). A brief statement, in English, regarding occurrence and utilization of ground water in Japan by the "Chief Hydro-Geologist to the Ministry of Agriculture and Forest." About two-thirds of the area of Japan is occupied by "Tertiary, Quaternary, and new igneous rocks," which are most promising for ground-water development. The older rocks are more uncertain, except subterranean channels in the Karst region.—*(From abstract by O. E. Meinzer) David G. Thompson.*

Beziehungen zwischen geologischen Aufbau und Wasserversorgung in Thüringen (Relations between Geologic Structure and Water Supply in Thuringia). F. Deubel. Beiträge zur Geologie von Thüringen (Thüringisch. Geol. Landesuntersuchung), H. 6: 54–69. March, 1928. This paper describes the general ground-water conditions in the three major geologic provinces of Thuringia, central Germany, in relation to the lithology.—*(From abstract by Arthur M. Piper) David G. Thompson.*

Wie lassen sich im Steinheimer Becker Thermal und Mineralquellen nachweisen? (How May the Presence of Thermal and Mineral Springs in the Steinheim Basin be Proven?). W. Ahrens, and A. Bentz. Heidenheimer Grenzbote, Nr. 64, March, 1928. This is a discussion of an earlier paper in the same publication which accepts the predictions of a water diviner that thermal and mineral waters exist in the Tertiary strata of the Steinheim Basin at depths from 40 to 60 meters. Present writers urge that the feasibility of such a venture should be investigated by a competent geologist.—*(From abstract by Arthur M. Piper) David G. Thompson.*

Permutit System in a Paper Mill. Paper Mill, 50: 52, 10, 12, 1927. From Chem. Abst., 22: 1817, May 20, 1928. Report of savings effected by Hammersley Manufacturing Company by installation of Permutit water softening plant.—*R. E. Thompson.*

Treatment of Water for Industrial Purposes. H. J. Wheaton. Paper Maker and Brit. Paper Trade J., 74: 589–96, 1927. From Chem. Abst., 22: 1817, May 20, 1928. Description of impurities present in natural waters and common methods of treatment.—*R. E. Thompson.*

The Method of Vorce for Determination of Minute Amounts of Phenol in Polluted Waters. F. Liebert and W. M. Deerns. Chem. Weekblad, 25: 103–5, 1928. From Chem. Abst., 22: 1817, May 20, 1928. The Vorce method (C.A. 20: 83) was examined. It was found that rubber or cork used in apparatus may contaminate sample. The hydrogen peroxide treatment must be carried out in the dark. Results with Folin and Wu reagent are often too high, other compounds reducing the reagent.—*R. E. Thompson.*

Technical Problems in Waste Utilization and Stream Improvement. C. M. Baker. Paper Trade J., 86: 8, 159–71, 1928; Paper Mill, 51: 8, 138–48, 152, 1928. From Chem. Abst., 22: 1818, May 20, 1928. Theoretical discussion of technical problems involved in effect of wastes upon streams, with description of sanitary analyses of wastes and stream water. Application of theoretical discussion is illustrated by surveys of Lower Fox and Wisconsin Rivers made by Bureau of Sanitary Engineering of Wisconsin State Board of Health and by pulp and paper industry of state, chemists of 14 pulp and paper mills co-operating in work.—*R. E. Thompson.*

The Prevention of River Pollution. F. A. B. Preston. Surveyor, 71: 177, 1927; cf. C. A., 22: 651. From Chem. Abst., 22: 1818, May 20, 1928. Discussion of methods of preventing stream pollution and of standards of stream purity. Effluents from gas works, iron and steel works, and coke-oven plants are very destructive to fish.—*R. E. Thompson.*

The Treatment of Beet Sugar Factory Effluents. O. Spengler. Surveyor, 73: 323, 1928. From Chem. Abst., 22: 1818, May 20, 1928. From experience in German factories, author recommends double fermentation process with combined lime supply (Hildesheim process) and fermentation and putrefaction, or Salzwedel process.—*R. E. Thompson.*

A Cutting Burner for Cast Iron. I. C. Fritz. Gas- u. Wasserfach, 70: 1048–9, 1927. From Chem. Abst., 22: 1876, June 10, 1928. Special type of oxy-acetylene cutting burner for cast iron has been devised, with heating burner on either side of cutting burner. Cast iron up to 6 inches in thickness can be cut satisfactorily.—*R. E. Thompson.*

Some Experiences in the Determination of Very Small Quantities of Iodides. J. T. Dunn. Analyst, 53: 211–2, 1928. From Chem. Abst., 22: 1926, June 10,

1928. For determining iodine in iodized salt, modification of method used by HUNTER (C. A., **4**: 431) and later by BRUBAKER and others (C.A., **20**: 3052–3) was found most satisfactory. Dissolve 50 grams salt in 250 cc. water, add few drops of sodium hypochlorite reagent and 1 to 5 cc. 40 per cent phosphoric acid. Boil few minutes to expel chlorine, cool, add 1 to 2 cc. 1 per cent potassium iodide and titrate with sodium thiosulfate. The hypochlorite oxidizes the iodine to iodate. Solution must be acid when boiled to remove chlorine and blank must be run on all reagents.—*R. E. Thompson.*

Newport's (England) New Water Supply Scheme. Munic. Eng. San. Record, **80**: 363, 1927. From Chem. Abst., **22**: 2017, June 10, 1928.—*R. E. Thompson.*

Determination of the Chlorine Value of Effluents. H. BACH and K. GLÄSER. Z. angew. Chem., **40**: 1115–6, 1927. From Chem. Abst., **22**: 1926, June 10, 1928. Chloramine is used instead of potassium hypochlorite as source of chlorine. Its 0.1 N solution is stable if kept in dark bottle. To filtered effluent, containing small quantity of 10 per cent sodium hydroxide to fix any carbon dioxide and so prevent liberation of chlorine from chloramine, is added a known volume of 0.1 N chloramine and mixture is gently boiled under specified conditions. Small quantity of 10 per cent potassium iodide is added, then concentrated hydrochloric acid, and, after some minutes, starch-zinc iodide solution, iodine being then titrated with 0.1 N thiosulfate. Blank must be treated similarly. Comparison of this method with potassium permanganate and biochemical oxygen-absorption methods show no general agreement in results.—*R. E. Thompson.*

Studies on the Transformation of Iron in Nature. II. The Importance of Microörganisms in the Solution and Precipitation of Iron. R. L. STARKEY and H. O. HALVORSON. Soil Science, **24**: 381–402, 1927; Cf. C.A., **22**: 1742. From Chem. Abst., **22**: 1990, June 10, 1928. Precipitation of iron from solution is not wholly dependent upon so-called "iron bacteria," but can be effected by large number of organisms acting in variety of ways. Organisms which decompose organic compounds of iron and therefore produce more iron ions, and also organisms which change environment, as by producing alkali, or by increasing oxygen pressure, are also important factors. Precipitation of ferric iron does not necessarily indicate that it has been recently oxidized, and oxidation may or may not result in precipitation of ferric iron, depending upon other conditions.—*R. E. Thompson.*

A Colorimetric Method for the Determination of Iron in Water. P. LEHMANN and A. REUSS. Z. Untersuch. Lebensm., **54**: 374–6, 1927. From Chem. Abst., **22**: 2018, June 10, 1928. Method dependent on formation of ferric thiocyanate.—*R. E. Thompson.*

A New Method for Determining the Colon Count in Water. L. V. WIKULLIL. Centr. Bakt. Parasitenk. I Abt., **104**: 460–3, 1927. From Chem. Abst., **22**: 1991, June 10, 1928. To each 100 cc. melted agar add: 0.1 gram m-phenylenediamine sulfate, previously dissolved and kept in 3 cc. water for several hours

or until it assumed yellowish color then neutralized with 0.5 cc. N sodium hydroxide; 1 gram lactose; 1 gram potassium nitrate; and 10 cc. of 1 per cent metachrome yellow R.D. (Grübler). Adjust pH to between 6.4 and 6.8. Gram-positive but not Gram-negative organisms are inhibited. Colon colonies are brown color. Fermentation of lactose produces acid, nitrate is reduced to nitrite and Bismarck brown is produced.—*R. E. Thompson.*

Preparation of Pure Water Without Distillation; Electroösmosis. PAUL PATIN. Chimie et industrie, **19**: 205–13, 1928. From Chem. Abst., **22**: 2017, June 10, 1928. Description of construction and operation of laboratory apparatus and commercial apparatus for electroösmotic purification of water. Product equal in purity to ordinary distilled water, or even to redistilled water, is obtained at much lower cost than by distillation.—*R. E. Thompson.*

Iron and Manganese in Water. HEINRICH THIELE. Gas- u. Wasserfach, **71**: 289–90, 1928. From Chem. Abst., **22**: 2018, June 10, 1928. Occurrence of iron and manganese in water and their removal discussed. Removal of iron and manganese by filtration is facilitated by certain organisms, such as Leptothrix, Crenothrix, Galionella, etc. If sufficient air is not available to oxidize the iron or manganese, oxidizing agents must be added, such as manganese dioxide precipitated on filtering material or mixed with it. Iron and manganese can also be removed by active charcoal.—*R. E. Thompson.*

The Importance of Proper Sampling in Water Analysis. WILHELM PLAHL. Z. Untersuch. Lebensm., **55**: 68–70, 1928. From Chem. Abst., **22**: 2017, June 10, 1928. Discussion.—*R. E. Thompson.*

Removal of Rust from Pipe Systems by an Acid Solvent. F. N. SPELLER, E. L. CHAPPELL and R. P. RUSSELL. Trans. Am. Inst. Chem. Eng., **19**: 165–71, 1927. From Chem. Abst., **22**: 2016, June 10, 1928. Description of initial applications of new method of removing rust and other substances from pipe systems. It is probably equally applicable to removal of rust from condensers, boilers, heaters, and other fabricated systems. Method consists in dissolving rust in acid rendered inert toward metal by addition of inhibitors. Solution is necessary not just loosening. General plan of cleaning operation illustrated by diagram. Removal required 5 to 6 hours with acid strength employed.—*R. E. Thompson.*

A Stable Standard Scale for the Determination of Nitrites in Waters. R. DANET. J. pharm. chim., **7**: 113–4, 1928. From Chem. Abst., **22**: 2018, June 10, 1928. Dissolve 0.1 gram fuchsin S in 1 liter water, place 0.3, 0.6, 0.9 and 1.2 cc. of this solution in 10-cc. tubes, make up to 10 cc. with camphorated water containing 1 per cent acetic acid and seal with paraffined corks. The 4 tubes correspond closely to water containing, respectively, 0.5, 1.0, 1.5 and 2.0 p.p.m. sodium nitrite when 10 cc. is treated with 1 cc. each of solutions of sulphanilic acid and α-naphthylamine, allowed to stand 20 to 30 minutes, and observed transversely.—*R. E. Thompson.*

Occurrence of Living Organisms in Water Mains. R. Kolkwitz. Gas- u. Wasserfach, 71: 268–9, 1928. From Chem. Abst., 22: 2018, June 10, 1928. Growth of algae and protozoa was found in curved pipe near outlet of centrifugal pump handling river water at pressure of 10 atmospheres. Alternate compression and release of pressure appeared to have no injurious effect.—*R. E. Thompson.*

Tannery and Leather Factory Sewage and Its Purification. A. Schulze-Forster. Gerber, 54: 39–40, 1928. From Chem. Abst., 22: 2076, June 10, 1928. Brief discussion.—*R. E. Thompson.*

Utilization of Heat in the Preparation of Boiler Feed Water. H. Balcke. Gesundh. Ing., 51: 209–16, 1928. From Chem. Abst., 22: 2018, June 10, 1928. Tests were carried out with iron plates suspended in solutions of various salts in small boiler. Formation of scale due to various salts which cause hardness in water is shown in series of photomicrographs. With water in which sulfate concentration was 3 times carbonate concentration and to which iron and silicates had been added, test pieces first showed deposit of rhombohedral needles of calcium carbonate. On further evaporation magnesium carbonate separated. With continued scale formation calcium sulfate was deposited in blunt broken up needles, or broad lamellar forms. If calcium carbonate was deposited in large amounts, deposition of calcium silicate took place at same time. Boiler tubes became coated with thin layer which was impervious to heat. If amount of calcium carbonate was slight, pure silicates separated in roset and pisiform formations. Photomicrographs of oxygen and carbon dioxide corrosion are shown. With oxygen, action is local and considerable pitting takes places. With carbon dioxide, metal appears to become porous and white deposits of calcium carbonate are visible. Chloride in small quantities is harmless, but in high concentrations it is very active. Since most plants return their condensate as feed water, it is highly advantageous to use distilled water for replacing loss within plant. Various evaporating and heat exchanging systems for this purpose are described and illustrated.—*R. E. Thompson.*

Volumetric Determination of Sulfate in Water. A. Bahrdt. Chem.-Ztg., 52: 163–4, 1928 cf. C.A., 21: 1506. From Chem. Abst., 22: 2018, June 10, 1928. Polemical.—*R. E. Thompson.*

Volumetric Determination of Sulfate in Water. M. Kehren and H. Stommel. Chem.-Ztg., 52: 164, 1928; cf. C.A., 22: 654. From Chem. Abst., 22: 2018, June 10, 1928. Polemical.—*R. E. Thompson.*

New Chlorine Preparations for the Sterilization of Drinking Water. W. E. Hilgers. Gesundh. Ing., 51: 177–84, 1928. From Chem. Abst., 22: 2017, June 10, 1928. Various chlorine preparations were tested, including "Kaporit" (calcium hypochlorite containing 60 to 75 per cent active chlorine), "Ergichlor" (sodium hypochlorite) and "aquapurol" (chlorine water in ampoules). Chloramine tablets were also tested. These are suitable for sterili-

zation in field, where water is fairly clear. Action is greatly retarded by high organic content. Sterilization with these tablets is slower than with chlorine water. Efficiency of various chlorine preparations is function of quality of water, number of bacteria present, the miscibility in water, and the stability or rate of evolution of chlorine. Control of drinking water by determination of free chlorine is not sufficient. Bacteriological tests should also be made.—*R. E. Thompson.*

Purification of Waste Water from Lignite-Distillation Plants. Dietrich Witt and Fritz Schuster. Gas- u. Wasserfach, 71: 241–4, 1928. From Chem. Abst., 22: 2018, June 10, 1928. Attempts were made to purify tarry turbid effluent from lignite-distillation plant which contained 0.06 per cent phenol and 49 grams hydrogen sulfide per cubic meter and required 3600 mgm. potassium permanganate per liter, by aëration, adding calcium hydrate, and filtering, adding ground clinker, lignite and alum, and peat and alum, with or without electrolysis in each case. Two latter methods, without electrolysis, gave clear nearly odorless effluents after 5 and 3 days, respectively. Method of purification finally adopted was to pass the water over low-temperature (Schwelkok) coke to remove hydrogen sulfide, then acidify slightly with flue gases, and finally pass water over fresh filter composed of washed coke. Latter is used as pre-filter as soon as it becomes ineffective as final filter. For this waste 4.6 per cent coke was used and rate of 1 gram water per gram of coke per hour was maintained on second filter. Effluent had only very slight odor, gave only slight turbidity with bromine water, required only 475 mgm. potassium permanganate per liter, and remained colorless even after standing 1 hour.—*R. E. Thompson.*

Local Developments at Llandudno (Wales). W. T. Ward. Munic. Eng. Sanit. Record, 80: 511–2, 1927. From Chem. Abst., 22: 2019, June 10, 1928. Water supply, derived from 2 natural lakes with capacity of 156 million gallons, is of excellent quality, containing less than 1 degree hardness. Water in all the lakes of district is pure and soft and is used without filtration.—*R. E. Thompson.*

The Purification of Swimming Bath Water. Inspection of Installation at Hornsey Baths (England). Munic. Eng. Sanit. Record., 80: 478, 1927. From Chem. Abst., 22: 2019, June 10, 1928. Purification plant includes centrifugal pumps, filters, aërator, heater, etc. Alum, soda, and chlorine are used. Plant, which cost £6500, is said to be largest and most modern of its kind in country. Water can be used 18–24 months.—*R. E. Thompson.*

Pigments for Iron and Steel Primers. E. W. Fasig and J. M. Purdy. Am. Paint and Varnish Mfrs.' Assocn., Circ. 319: 611–22, November, 1927. From Chem. Abst., 22: 2069, June 10, 1928. General dissertation on rusting and rust prevention, together with details of tests on number of pigments when placed in wet contact with steel. Results of tests, which were still proceeding, indicated that among foremost rust inhibitors, litharge compares favorably with zinc chromate. Suggested that red lead pigments with as much as 10

per cent free litharge are preferable to pure red lead in this connection.—*R. E. Thompson.*

Composition of Bleaching Powder. C. T. KINGZETT. J. Chem. Soc., 1928, 528. From Chem. Abst., 22: 2034, June 10, 1928. Formula $Ca(ClO)_2 \cdot 4H_2O$ represents only the composition of substance as separated in more or less wet condition by rapidly drying between sheets of filter paper.—*R. E. Thompson.*

Practical Problems of Corrosion. III. Formation of Rust and Its Consequences. U. R. EVANS. J. Soc. Chem. Ind., 47: 55–62T, 1928; cf. C. A., 22: 1318. From Chem. Abst., 22: 2135, June 20, 1928. Composition of, and volume occupied by rust are discussed. Mechanism of formation of rust varies for different waters, rust in general not being formed at seat of corrosion. Hard waters produce rust films containing calcium and magnesium compounds which, being deposited at cathodic portions, decrease corrosion by obstructing diffusion of oxygen. Magnesium sulfate was found to reduce corrosion of partially immersed specimens. Loose rust films, if continuous, will protect underlying metal, otherwise such films will promote pitting. Formation of voluminous corrosion products may cause disintegration of coatings or of the metal itself. **IV. The Corrosion of Wrought Iron in Relation to That of Steel.** Ibid., 62–9T. Initial attack of acids on wrought iron is much slower than on steel, but velocity increases with time until attack is much more rapid. Loss of weight is no indication of depth of pitting. Corrosion by rain water is not usually of the hydrogen evolution type; consequently acid type of attack on wrought iron does not take place in this case. Under anodic corrosion produced by stray currents, wrought iron will form shallower and broader pits than steel because of resistant planes of silicate. For this reason wrought iron possesses advantage over steel in resisting corrosion by stray currents underground, although extra precautions in providing protective coatings might possibly show better economy in use of steel pipe. Concluded that in general under favorable conditions steel and wrought iron will have equal life, but that because of its structure wrought iron will have advantage in deflecting attack of intense localized character. **V. Corrosion and Protection at the Contacts of Dissimilar Metals.** Ibid., 73–7T. Copper is usually cathodic to steel, zinc anodic, while tin and lead are variable. Contact of steel with copper in salt solutions accelerates corrosion of steel, and lead causes slight acceleration. Hardness of water decreases contact effect. Zinc affords complete protection to steel in most liquids, although at expense of zinc in salt solutions.—*R. E. Thompson.*

Corrosion in Ice Plants. H. L. LINCOLN. Power, 67: 688–9, 1928. From Chem. Abst., 22: 2136, June 20, 1928. Corrosion is decreased when pH of brine is maintained between 8 and 9.—*R. E. Thompson.*

The Biological Significance of the Salt Concentration of Natural Waters. CARL SCHLIEPER. Naturwissenschaften, 16: 229–37, 1928. From Chem. Abst., 22: 2176, June 20, 1928. A review.—*R. E. Thompson.*

Purification of Water from Rivers Polluted by Sisal Effluent. F. C. Kelly. Kenya Med. J., 3: 212–5, 1926; Bull. Hyg., 2: 651, 1927. From Chem. Abst., 22: 2223, June 20, 1928. Sisal waste markedly increases both albuminoid nitrogen and absorbed oxygen. Absorbed oxygen test furnishes excellent indication of sisal pollution because of marked reducing properties of some unidentified constituent. Fish life, but not that of frogs, is destroyed by it. Filtration is effective in overcoming the pollution.—*R. E. Thompson.*

Chlorination of Water Supplies in Assam. R. T. Sen. Proc. Assan. Branch British Med. Assocn., 1926: 43–5; Bull. Hyg., 2: 649, 1927. From Chem. Abst., 22: 2224, June 20, 1928. Dechlorination of supplies treated with excess chlorine recommended.—*R. E. Thompson.*

Deferrization, Aëration, and Filtration of Industrial Waters. A. Langumier. Arts et métiers, 90, 96–109, March, 1928. From Chem. Abst., 22: 2224, June 20, 1928. Descriptive.—*R. E. Thompson.*

The Methods for Determining Sulfur Trioxide in Natural Waters and Soil Extracts. B. G. Zaprometov. Bull. Univ. Asie Centrale (Tachkent), 1927, 91–5. From Chem. Abst., 22: 2224, June 20, 1928. Gravimetric, iodometric titration, and benzidine methods compared, latter being found best. Method is simplified by omitting filtration of benzidine sulfate with suction.—*R. E. Thompson.*

Feed Water for World's Largest Boilers Receives Zeolite and Acid Treatment. Alfred H. White, J. H. Walker, Everett P. Partridge and Leo F. Collins. Power, 66: 90–4, 1928. From Chem. Abst., 22: 2224, June 20, 1928. Beacon Street heating plant of Detroit Edison Co., supplying steam for heating in business district, contains 12 boilers each of 41,500 square feet of heating surface. High alkalinity resulting from zeolite treatment is corrected by addition of 35 p.p.m. sulfuric acid. H-ion concentration is recorded in storage reservoir and as water leaves feed-water heater. Acid neutralizes about one-half sodium bicarbonate present. The pH is 6.5 before deaëration and 8.5 after. Continuous blowdown through heat exchanger is satisfactory. After 8 months' operation the tubes were clean and there had been no tube burnouts or serious corrosion.—*R. E. Thompson.*

Lime and Soda Treatment of Feed Water. E. M. Partridge. Power, 67: 507–9, 1928. From Chem. Abst., 22: 2224, June 20, 1928. Partial softening with lime and soda may increase corrosive properties and result in formation of scale which is harder, though less in amount, than formed from untreated water.—*R. E. Thompson.*

Regulating the Density of Milk of Lime. L. D'yachuk. Nauchnuie Zapiski (Russian), 5: 285–7, 1928. From Chem. Abst., 22: 2286, June 20, 1928. Detailed, illustrated description of new type regulator which controls introduction of lime during process of saturation, etc. It is automatic, easy to clean, and simple in construction.—*R. E. Thompson.*

Coagulation Processes in the Purification of River Water. C. P. Mom. Mededeel. Dienst Volksgezondheid Nederland. Indie, 17: 1–12, 13–9, 1928. From Chem. Abst., 22: 2223, June 20, 1928. Coagulation of colloidal clay in water of Tjiliwong by means of lime was investigated. Removal of excess lime with lime-absorbing materials gave unsatisfactory results. Difficulties in removing excess lime are not sufficiently compensated for by advantages of sterilizing effect of lime. Coagulation with iron sulfate and lime was also investigated. Sterilizing effect when treating water rich in alkali is great advantage. Disadvantages are: (1) difficulty of neutralizing alkalinity after coagulation and (2) reducing action of iron sulfate, requiring additional oxygen in oxidizing the water.—*R. E. Thompson.*

The Action of Pure Water on Quick-Setting Cements. Mourral. Génie civil, 92: 121–2, 1928. From Chem. Abst., 22: 2253, June 20, 1928. Contrary to popular opinion pure water does not readily break down quick-setting cements such as used in water mains. If pure ingredients are used and mix is rich, good results may be expected. At least 7 installations over 20 years old are still in good condition.—*R. E. Thompson.*

Phenol-Recovery Plant Avoids Waste Pollution of Streams. H. E. Jones. Chem. Met. Eng., 35: 215–8, 1928. From Chem. Abst., 22: 2258, June 20, 1928. Phenol is extracted continuously with efficiency of 96 per cent from crude ammonia liquor of coke plant by motor benzene, which is then stripped of phenol by washing with 23 per cent sodium hydroxide. Sodium phenolate thus formed, upon acidification with sulfuric acid, yields crude phenol of following volumetric composition: phenol 54, cresols 23, water 16 and tarry matter 7 per cent.—*R. E. Thompson.*

Oxidation Processes in the Purification of River Water. C. P. Mom. Mededeel. Dienst Volksgezondheid Nederland. Indie, 17: 21–32, 1928. From Chem. Abst., 22: 2223, June 20, 1928. Methods of oxidizing organic matter which occurs in river water and hinders coagulation were studied. Catalytic influence of sunlight and colloidal clay on decomposition of potassium permanganate, chlorine, and Caporite demonstrated. (Latter is a Griesheim Electron preparation of calcium hypochlorite with content of so-called active chlorine of about 70 per cent. It is fairly stable and can be kept for long time. Chemically and physiologically, it is practically as active as liquid chlorine and in many cases can replace latter, cf. Geneeskundig Tijdschrift voor Nederland. Indie 63, No. 6, 1923.) Sunlight brings about decomposition more quickly and affects these oxidizing agents favorably, particularly potassium permanganate. Colloidal clay advances decomposition of both permanganate and Caporite. In flocculated form clay does not act as strongly. Chlorine gas acted practically the same as Caporite. Colloidal kaolin has no influence upon decomposition of permanganate, but it does influence that of Caporite. In practice, pH generally proves to be of little importance.—*R. E. Thompson.*

An Instrument to Record the Carbon Dioxide Content of Gaseous Mixtures. K. Gordon and J. F. Lehmann. J. Sci. Instruments, 5: 123–6, 1928. From

Chem. Abst., 22: 2294, July 10, 1928. Apparatus is based on variation in conductivity of bicarbonate solution in equilibrium with saturated carbonate solution, and independent of other constituents of gaseous mixture. Barium carbonate is used.—*R. E. Thompson.*

Flow Meter. H. Winkelmann. Apparatebau, 40: 99–100, 1928. From Chem. Abst., 22: 2294, July 10, 1928. Grefe meter described.—*R. E. Thompson.*

Softening Water in Small Quantities. A. Battige. Apparatebau, 40: 89–90, 1928. From Chem. Abst., 22: 2421, July 10, 1928. Description of small lime-soda plant.—*R. E. Thompson.*

Physical Factors on the Sandy Beach. II. Chemical Changes—Carbon Dioxide Concentration and Sulfides. J. R. Bruce. J. Marine Biol. Assocn., 15: 553–65, 1928. From Chem. Abst., 22: 2383, July 10, 1928. Conditions leading to formation of "black layer" are surveyed and discussed, with special reference to Port Erin beach. An iodometric method for determination of sulfides in sand is described, and is used to demonstrate rate of oxidation when black sand is exposed to air. Concluded that formation of iron sulfide in sand is associated with diminished circulation of air and water in mass of sand, due either to gross obstruction, or to fineness of grade, or to both. Presence of organic detritus, usually of algal nature, appears to be essential to reaction, and bacteria play important rôle in sequence of changes. Sulfur, in common with other elements, passes through cycle of reactions on sea bottom and in sandy beach.—*R. E. Thompson.*

Sodium Aluminate as an Aid to Water Softening. Committee Report Am. Ry. Eng. Assocn., Railway Age, 84: 560–5, 1928. From Chem. Abst., 22: 2421, July 10, 1928. In soda-lime process, using 1 to 3 grains per gallon of alum or of iron sulfate, the hydroxides formed cause the light magnesium hydroxide particles to settle more quickly and aid in freeing softened water from calcium carbonate. Latter separates from solution slowly and causes after-precipitation and scale in pipe lines. If sodium aluminate instead of alum or iron sulfate is used, more rapid and complete precipitation occurs. Optimum dosage is 1½ grains per gallon.—*R. E. Thompson.*

Electroösmotic Water Purification. A. H. W. Aten. Chem. Weekblad, 25: 211–9, 1928. From Chem. Abst., 22: 2421, July 10, 1928. Description of apparatus and results. Product was within limits of requirements for distilled water (Dutch Pharm.) for dissolved salts, organic matter being equal to 0.8 to 1.0 cc. 0.01 N potassium permanganate per 100 cc. and solid matter, 1.0 to 1.4 mgm. per 100 cc. Bacterial count was reduced from 500 to 2. Cost compares favorably with ordinary distillation. Corrosion of diaphragm is most serious drawback.—*R. E. Thompson.*

The Chlorination of Water. L. W. Haase. Gas- u. Wasserfach, 71: 385–90, 1928. From Chem. Abst., 22: 2421, July 10, 1928. In water containing

carbonate, chlorine reacts in usual way to give calcium hypochlorite and calcium bicarbonate. Presence of organic matter may act as "catalytic accelerator" by reacting with the chlorine, hydrolyzing, and resulting hydrochloric acid reacting with calcium carbonate to give calcium bicarbonate. Portion of chlorine will also react to form chlorides. Above reactions result in pH changing toward acid side (pH 8–9 to 6–7), and may result in increase in permanent and temporary hardness, depending on amount and nature of organic matter and amount of carbonate present. Addition of small quantities of lime is suggested as means of avoiding corrosion when carbonate concentration is low.—*R. E. Thompson.*

Boiler Feed Water Purification, the "Neckar" System. G. J. Flux. Het Gas, 48: 115–22, 1928. From Chem. Abst., 22: 2422, July 10, 1928. "Neckar" system consists of treatment with soda and heat. Alkalinity used was between 5 and 10 cc. 0.1 N hydrochloric acid per 50 cc. water. Deposits found in waste heat boiler after prolonged use consisted mainly of silica (from colloidal sodium silicate). Calculated that this danger can be avoided by 7.2 per cent blowdown.—*R. E. Thompson.*

Cementation of Strata Below Reservoir Embankment. A. A. Barnes. Munic. Eng. Sanit. Record, 79: 628, 1927. From Chem. Abst., 22: 2423, July 10, 1928. Series of holes was bored into which mixture of 1 part slow setting cement and 20 parts water was poured. This was repeated twice, leakage of over 1 million gallons per day being finally stopped. Another method employed was forcing of grout under special conditions into cleaned boreholes.—*R. E. Thompson.*

Municipal Works and Statistics of Spenborough (England). A. Rothera. Munic. Eng. Sanit. Record, 79: 517–8, 1927. From Chem. Abst., 22: 2423, July 10, 1928. Description of water supply.—*R. E. Thompson.*

Soundness of Cements in Corrosive Waters. G. Haegermann. Zement, 16: 1190–2, 1927; cf. C.A., 22: 1663. From Chem. Abst., 22: 2449, July 10, 1928. Mortar tests bore out earlier observations that cements with high silica or ferric hydroxide content, but low alumina, resist action of sulfate solutions. Lime content alone is no criterion of durability of cement.—*R. E. Thompson.*

A Photoelectric Turbidity Meter. L. W. Haase and Heinrich Thiele. Gas- u. Wasserfach, 71: 414–7, 1928. From Chem. Abst., 22: 2496, July 20, 1928. The water is placed in cylinder 300 mm. long and 35 mm. in diameter, provided with selenium cell at one end and flashlight lamp at other. Storage battery, or step-down transformer, may be used to supply lamp, which is maintained at constant brightness by maintaining constant current. Change of resistance of selenium cell is measured by means of slide-wire bridge. Methods of operation are described which eliminate usual errors due to slow recovery of cell after illumination. Cell is calibrated with definite percentages of silica in suspension.—*R. E. Thompson.*

Volumetric Displacement Apparatus for Controlling the Supply of Gas for Chlorinating Water or Similar Processes. B. Bramwell. Brit. 277, 869, March 16, 1927. From Chem. Abst., **22**: 2497, July 20, 1928.—*R. E. Thompson.*

Electric System for Preventing Corrosion of Water Mains, etc. E. Cumberland. Brit. 277, 417, June 15, 1926. From Chem. Abst., **22**: 2518, July 20, 1928.—*R. E. Thompson.*

Experimental Plants in Water Treatment. Harry N. Jenks. Water Works Eng., **82**: 12, 721, June 5, 1929. Experimental plant enables the engineer to determine practical and economical methods of operation. Description of the Sacramento experimental plant gives details of various units which included aërator, grit basin, mixing tanks, settling basin, and rapid sand filter. The rate of flow thru this plant was 2 g.p.m. A similar plant was built at Iowa State College. An experimental iron removal softening plant at Fort Dodge enabled the engineers to satisfactorily study spray nozzles and stream flow aëration. A complete laboratory set-up enabled any part of the process to be checked. Three weeks were required to build plant and four weeks to obtain requisite design and operating data. The approximate cost was $600.00.—*Lewis V. Carpenter.*

Elevated Storage. Smoothing the Peaks. Donald H. Maxwell. Water Works Eng., **82**: 12, 723, June 5, 1929. The purpose of elevated storage is to tide over interruption in pumping, to smooth out peaks in demand, for fire protection, and to improve pressures. For smoothing out peaks, the required storage is about 15 per cent of the 24-hour pumpage rate. In towns purchasing power it is advantageous to have sufficient storage to shut down during peak load. In small plants, the fire pumpage is large compared to the domestic, and elevated storage reduces the pumping equipment. Storage should be shallow. Elevated storage should be located remote from pumps and on the opposite side of the principal district served.—*Lewis V. Carpenter.*

Wood Pipe Line Replaced by Concrete. W. A. Kunigk. Water Works Eng., **82**: 11, 663, May 22, 1929. Tacoma, Wash., replaced with centrifugally spun reinforced concrete pipe 14,500 feet of wooden pipe which had been in service since 1913. Town had prepared specifications for deliveries of 63-inch and 51-inch electrically welded pipe made up from $\frac{5}{16}$-inch plate. The specifications for centrifugally spun reinforced concrete pipe required it to be furnished and installed with a two-year maintenance bond. Concrete pipe was cheapest complete. Pipe that was tested to 125 per cent of the safe working stress was to show no appreciable seepage or cracks after a 20-minute test. Entire job was entirely satisfactory. Article gives some details on the manufacture of the pipe.—*Lewis V. Carpenter.*

Rapid Sand Filters That Have Given Long Service. James M. Caird. Water Works Eng., **82**: 11, 670, May 22, 1929. Following a typhoid epidemic rapid sand filters of the Jewell High Type were installed in Elmira, N. Y., in 1897. Plant now consists of 24 units with a total sand area of 6424 square

feet and a rated capacity of 8,000,000 g.p.d. Original filters were cedar with replacements of swamp cypress. Forty-eight inch layer of sand of effective size 0.56 mm. and of uniformity coefficient 1.43 is used. Strainers had to be repaired every seventh year. The lateral pipes lasted about 20 years. New pipe with holes down is being used to replace strainers. Average amount of wash water is 2.78 per cent. Sulphate of alumina is used as coagulant. Liquid chlorine replaced hypochlorite in 1916. The bacterial reduction with alum only was 98.35 per cent, with calcium hypochlorite in addition, 99.90 per cent and with liquid chlorine it further increased to 99.93 per cent. Turbidity has ranged from 2 to 10,000; color from 2 to 180; and alkalinity from 11 to 165 p.p.m. The coagulation period is twenty minutes.—*Lewis V. Carpenter.*

Court Decisions and the Water Works. LEO T. PARKER. Water Works Eng., 82: 11, 651, May 22, 1929. Court ruled in case of City of Kirkwood, Missouri, that "water corporation" does not apply to municipalities operating water works. The Court ruled that the city could extend water service outside of town without securing permission from the Public Service Commission.

Pejepscot Paper Company sued Town of Lisbon for alleged over payments. The industrial water rate filed with Public Service Commission was much lower than the rate for offices. Two separate bills were sent to the paper company, one for industrial use and the other, at a much higher schedule, for office use. Court ruled that the classification was proper and that the company should pay a higher rate for water used in offices, restaurant, etc.

In City of Memphis *vs.* BROWDER, the court held a contract invalid by which the city granted the owner of a water works system a franchise for supplying water to the city and citizens for twenty-five years at a fixed rate. Court ruled that it was giving a monopoly to the water company and that the state laws prohibited monopolies.—*Lewis V. Carpenter.*

Proceedings, Eleventh Texas Water Works Short School, 1929. Sanitary Protection of Watersheds and Reservoirs. E. SHERMAN CHASE. pp. 119–123. It is man and man's activities which must be guarded against. With the advent of improved methods in the purification of water supplies, there has been a tendency in some quarters to minimize the value of protective measures. Where watersheds and reservoirs are owned in large part by the municipality, strict sanitary oversight of the water shed and reservoirs can and should be maintained. To utilize water supply reservoirs as a means of recreation on the plea of fullest economic utilization of such reservoirs is false economy. **Preservation of Metal Water Tanks.** J. H. DAVIDSON. pp. 102–105. Steel tanks used in water supply need protection against corrosion. Materials commonly used are listed with comments. Directions are given for use of cement grout as a protective coating. **The Sterilization of New Water Mains.** E. C. SULLIVAN. pp. 105–109. A review of current practice with a list of references. **Electric Drive for Water Pumping.** F. C. BOLTON. pp. 109–114. Electric drive for water pumps has many advantages. Discussion of factors to be considered in selecting proper type of drive, pumps, motors and motor control. **Cause and Elimination of Tastes in Chlorinated Water.** O. M. BAKKE. pp. 100–102. **Mixing and Coagulation in Water Works Practice.** M. P. HATCHES. pp. 96–97.

A brief review of theory and practice in design of mixing and coagulation basin in water purification. **Mechanics of Well Construction and Laws of Yield.** J. G. Montgomery. pp. 69–73. Test wells should be put down to determine the best place to locate permanent wells. The principal methods of drilling are described with a discussion of the factors involved in location of wells and selection of type and size. **Some Underground Waters of West Texas and Their Geological Horizons.** H. N. Roberts. pp. 82–90. **An Underground Water Research at Big Spring, Texas.** John B. Hawley. pp. 91–95.—*John H. O'Neill.*

Iodine and Goitre. Editorial, Jour. American Medical Association, **92:** 2172. The view that a deficiency of iodine in the diet is the chief factor in the etiology of simple thyroid enlargement has become well established by repeated demonstrations of prophylaxis and cures, both in experimental animals and in man.—*John H. O'Neill.*

An Iodine Survey of Nebraska. W. H. Adolph and F. J. Prochaska. Jour. American Medical Association, **92:** 2158–2160, June 29, 1929. Report of investigation of iodine content of water and food supplies. Nebraska water supplies contain sufficient iodine for the maintenance of thyroid equilibrium. Nebraska food materials are not low in iodine content. Simple goitre is not prevalent and Nebraska can be properly grouped as one of non-goitrous states.—*John H. O'Neill.*

Some Problems in Engineering Geology. Edgar Morton. Water and Water Eng. **31:** 364, 153–156, April 20, 1929. The writer first discusses use of stone in construction work and then considers structural geology with relation to surface and subterranean water supply problems. The continued need for accessible catchment areas and the increase in shortage of such areas give cause for scientific study of the relationships existing between the flow of water on catchment areas and structural geology. The formula of Hawksley for obtaining the yield of a given catchment area, together with the modified one of Rofe, may both be subject to error in that they disregard the influence of structural geology. For example, the rocks in the Pennines, consisting of an alternating series of pervious sandstones or limestones and impervious shales, act as natural storage reservoirs, tending to equalize the run-off and deliver it up gradually. Catchment areas having such geological formation will probably yield a considerable dry weather flow, thereby reducing storage requirements. Further percolation into the sandstones may return to the surface in its own catchment area, or, on the other hand, may reissue in another area. These examples imply that figures on available yield of a particular area and on the size of equalizing storage reservoirs as determined by formulae are subject to modifications which may result from an investigation of the geological structure of that area. The determination of the extent of underground water resources is becoming more urgent as the number of wells being sunk increases. The first step in the solution of this problem is to determine the extent of water-bearing formations. This is something which cannot be ascertained with any great degree of accuracy theoretically, but

must be attacked from a practical viewpoint. "Each water-bearing formation should be divided into convenient regions, determined preferably by subterranean watersheds, data being accumulated as to the yield, rest, pumping levels, draw of wells and boreholes under given conditions, and their influence on surface springs and streams ascertained for each region." Such information considered in connection with geological character and structure of pervious beds would provide a basis for estimating the yielding capacity of each area.—*Arthur P. Miller.*

The City of Bésançon Filtering Wells and Pumping Stations. Anon. Water and Water Eng. 31: 364, 156–158. April 20, 1929. In 1922 it became necessary to increase the water supply of Bésançon. Following the example of an industry, three filtering shafts were sunk into the Doubs alluvial beds less than 2 miles upstream from the city. These concrete shafts were about 13 feet in diameter, 87 yards apart, and sunk to a depth of 20 feet into the thick gravel deposits at a point about 55 yards from the river. They were continued above ground by a tower 23 feet high and surrounded by a sloping bank of clay to prevent contamination. The gravel acts as a filter bed and each tower can supply 61 tons of water in 24 hours. Inasmuch as the adjacent river is liable to sudden floods, the motors in the towers are arranged so as to be rapidly removable to an upper floor. The writer also discusses some pumping installations in various parts of the city.—*Arthur P. Miller.*

A Practical Suggestion for Dealing with the Unemployment Question: the Provision of Piped Rural Water Supplies. D. F. Worger. Water and Water Eng., 31: 364, 161–4, April 20, 1929. Discusses at some length the provision of piped water supplies in rural areas, with particular reference to its suitability as a means of reducing unemployment. No class of work could so greatly benefit the unemployed, taking the entire Kingdom as a whole, as the provision of a water supply to the large portion of the 6,000,000 people now so urgently needing it. A piped water supply is one of the amenities which the householder or the new house builder seeks first. This rising trend in the plane of living of the urban population, together with such other factors as public health activities, have contributed to a steady improvement in the quality of rural waters. There still remains much to be done, however, and the report of the Advisory Committee on Water of the Ministry of Health (England) has given a number of suggestions for stimulating this further improvement.—*Arthur P. Miller.*

Story of the Efforts Which Led to the Purification of the Water Supply of Pittsburgh and to the Elimination of Typhoid Fever from that Cause. James Otis Handy. Proc. Eng. Soc. West. Penna., 43: 3, 179, April, 1927. Describing preliminary activities, experimental filtration tank, the personnel, and showing deaths from typhoid fever per 100,000 population and per 10,000 population from 1893 to 1926 inclusive, bringing out the comparison between the periods before and after the installation of a slow sand filtration plant.—*E. E. Bankson.*

Engineering Analysis Applied to Municipal Water Works. Wm. Shaw. Proc. Eng. Soc. West. Penna., **44**: 2, 47, March, 1928. The object of this study is to determine which will prove the more economical, (1) To expend money for the improvements necessary for the continued successful operation of the present steam operated pumping station, or (2) To erect a new station equip-the with electrically driven pumping units at Brilliant Pumping Station of ped Pittsburgh, Pa., Water Works, comparing rehabilitation in the one case with design of new work in the other case, as well as comparing low interest rates and absence of taxes for municipal finance with the higher interest rates and liability to taxation for finance of private corporations.—*E. E. Bankson.*

A Century of the Pittsburgh, Pa., Water Works. E. E. Lanpher. Proc. Eng. Soc. West. Penna., **44**: 10, 331, January, 1929. Covering the period from 1802 to 1928 inclusive. History.—*E. E. Bankson.*

Life of Wood Pipe. J. P. Leaf. Proc. Eng. Soc. West. Penna., **44**: 10, 340, January, 1929. Description, with sample submitted, of wood pipe for water service, made from white oak logs with 2½-inch bore, after continuous service from 1824 to 1915.—*E. E. Bankson.*

Statistics of Typhoid Fever in Pittsburgh, Pa. C. F. Drake. Proc. Eng. Soc. West. Penna., **44**: 10, 347, January, 1929. Complete vital statistics, showing the incidence of typhoid fever in Pittsburgh during the past 55 years, so far as statistics are available.—*E. E. Bankson.*

Purchasing Public Utility Power for Industrial Use. W. B. Skinkle. Proc. Eng. Soc. West Penna., **45**: 2, 57, March, 1929. A detailed and fundamental comparison of purchased electric power with that generated in a privately owned station, including discussion relative to line losses, controlling devices, analyses of various types of schedules which may apply for pumping water as well as for industrial use.—*E. E. Bankson.*

Some Interesting Construction Problems. Morris Knowles. Penna. Water Works Ass'n. 1927 Report, 20. Describing Lynn, Mass., outfall sewer and Chichopee, Mass., impounding dam, dealing with practical problems of construction.—*E. E. Bankson.*

The Centralization of Ownership of Pennsylvania Water Companies. Farley Gannett. Pennsylvania Water Works Ass'n. 1927 Report, 60. Defining the activities and ownership of water companies in Pennsylvania by six holding companies as follows: (1) American Water Works and Electric Company. (2) Community Water Service Company. (3) Federal Water Service Company. (4) North American Water Corporation. (5) Consumers Water Company. (6) Philadelphia Suburban Water Company.—*E. E. Bankson.*

The (Pennsylvania) State's Efforts to Protect Public Water Supplies. W. L. Stevenson. Pennsylvania Water Works Ass'n. 1927 Report, 85. Describing and defining the activities of the Sanitary Water Board and dealing also with

"Recreational Use of Watersheds" and protective measures in connection therewith.—*E. E. Bankson.*

Stream Pollution and its Remedy. Grover C. Ladner. Pennsylvania Water Works Ass'n. 1927 Report, 99. Dealing with Court decisions, statutory law; with the conclusion that "the pure stream movement is just and right and must ultimately prevail."—*E. E. Bankson.*

Decisions of the Courts and Public Service Commission of Penna. During the Year Affecting Water Companies. Edgar Munson. Pennsylvania Water Works Ass'n. 1927 Report, 127. Analyzing and classifying decisions affecting water companies in the State of Pennsylvania.—*E. E. Bankson.*

Some Legal Aspects in the Consolidation of Water Companies. Spencer G. Nauman. Pennsylvania Water Works Ass'n. 1927 Report, 168. Dealing with the general attitude of the Pennsylvania Public Service Commission towards consolidation and municipal ownership.—*E. E. Bankson.*

Improving Public Service Through Parent Companies. V. Bernard Siems. Pennsylvania Water Works Ass'n. 1927 Report, 180. Dealing with organization; comparison of private ownership by parent company and municipal ownership financing; and recommendations.—*E. E. Bankson.*

Municipally and Privately Owned Water Utilities. Some Observed Differences. Reeves J. Newsom. Pennsylvania Water Works Ass'n. 1927 Report, 194. Contrasting the conditions of operation for municipally owned water works plants with those surrounding the operation of the privately owned water utility, pointing out inefficiencies and political relationship for the municipally owned plant.—*E. E. Bankson.*

Present Status of the Valuation Problem under Recent Federal Decisions. Jos. A. Beck. Pennsylvania Water Works Ass'n. 1927 Report, 208. Dealing with the decision of the United States Supreme Court in the case of McArdle et al. *versus* the Indianapolis Water Company and the decision of the Interstate Commerce Commission relating to "excess income" of St. Louis and O'Fallon Railway Company under the recapture provisions of the 1920 transportation act.—*E. E. Bankson.*

Public Service and Public Trust. E. A. Geehan. Pennsylvania Water Works Ass'n. 1928 Report, 21. So long as our industry continues to manage with efficiency, to finance with honesty, and to tell the truth about its business, there is no reason to expect any change of opinion on the part of the public and we will continue to enjoy the good will and high esteem that our industry now does.—*E. E. Bankson.*

Decisions of the Courts and Public Service Commissions during the Year. Affecting Water Companies (in Pennsylvania). Edgar Munson. Pennsylvania Water Works Ass'n. 1928 Report, 27. Analyzing and classifying decisions affecting water companies for the past year.—*E. E. Bankson.*

The Stream Pollution Problem in Pennsylvania. W. B. McCaleb. Pennsylvania Water Works Ass'n. 1928 Report, 83. Reviewing the situation and quoting from the decision in the Indian Creek Case, "No language used in the Sanderson opinion can be tortured into an implication that the waters of the Commonwealth can be polluted by its mines where the public is affected as it is here. . . . . Our conclusion is that the defendants have no right of any kind to drain their mine water into the stream considering the public use which is made of its waters and that their *so doing constitutes a nuisance which must be restrained.*" After procrastination the coal companies were declared in contempt of Court and then the four largest coal operators constructed a drainage tunnel and flume, thereby to convey the mine drainage to a point below the dam which impounded the domestic water supply, at a cost of over $500,000. And later the Court granted an order directing the small operators to seal their mines within thirty days and finally at the hands of the Sheriff, under Court order, some twenty small mine openings were permanently sealed with concrete. And there are further discussed the activities of the Sanitary Water Board in the Department of Health, other methods of treating mine wastes, and finally, protection of domestic water supply through reforestration and the regulation of stream flow by the construction of large reservoirs for impounding flood flows. Also quoting that "The City of Philadelphia and the State of Pennsylvania won an important victory in the fight against pollution of the Schuylkill River by a Court order and decree that the Coopers Creek Chemical Company, of Upper Merion, 'shall not permit any tarry or other medicinal-taste producing substances to flow or escape from their plant into the Schuylkill River or its tributaries.' "—*E. E. Bankson.*

Status of Water Purification in Pennsylvania. H. E. Moses. Pennsylvania Water Works Ass'n. 1928 Report, 101. To-day in Pennsylvania more than 6,000,000 people are supplied with water through 650 public water works. Nearly every town in the State of over 2500 population has a public water supply and most places of over 1000 are also supplied. The first public water works in the United States was that of Boston, built in 1652. The first in Pennsylvania was in 1736 at Schaeffertown, while the first water works pumping plant in the United States was installed at Bethlehem, Pa., in 1754, and the first filtration plant in Pennsylvania, at New Bethlehem, Pa., in 1889. Progress of filtration plants in Pennsylvania is recorded for the period from 1889 to 1928 to a total of 194 plants, consisting of 1004 filter units, having a rated capacity of 1120 and producing a daily filtered water supply of 762 m.g.d. to a population of more than 4¾ millions. Deals also with germicidal treatment of water in Pennsylvania by chlorine, copper sulphate, and chlorinated lime. To contain the filtered water served daily would be required 63,333 tank cars, or a train 465 miles in length extending along the Pennsylvania Railroad tracks from Puiladelphia to Pittsburgh and beyond, to the State line with a surplus over in Ohio, containing enough water to serve the daily needs of Erie, Reading, Scranton, and Wilkes-Barre combined. Deals also with reduction in death rate from typhoid fever in the registration area in the United States from 35.9 per 100,000 population in 1900 to 8.0 per 100,000 population in 1925, or a reduction of approximately 78 per cent.—*E. E. Bankson.*

Effect of Storage Reservoir upon Stream Pollution and Water Supplies. RALPH J. FERRIS. Pennsylvania Water Works Ass'n. 1928 Report, 114. The primary purpose of the Pymatuning (Pennsylvania) reservoir project is to provide an adequate water supply during the dry season for domestic and industrial uses in the Shenango and Beaver Valleys and for the proper dilution of sewage. The proposed reservoir will have an area of 18,000 acres and will contain 74 billion gallons of water. It will reduce floods by 25 per cent and increase dry weather discharge by 2000 per cent, or from 112 gallons to 3000 gallons per second. The present pumpage from the Shenango River is 18 times the minimum flow.—*E. E. Bankson.*

Proposed Pollution Legislation in Pennsylvania. N. B. JACOBS. Pennsylvania Water Works Ass'n. 1928 Report, 133. Dealing with existing Pennsylvania laws, shortcomings of existing laws, governing considerations in drafting new laws, and the conclusion that Pennsylvania should have a pollution law which does not prohibit the discharge of waste and at the same time does not permit, or provide for the issuing of permits, to discharge waste into the waters of the State.—*E. E. Bankson.*

Water Works State Regulation. F. HERBERT SNOW. Pennsylvania Water Works Ass'n. 1928 Report, 139. We are now in the era of big business. All kinds of enterprises are being consolidated and merged and among others the water works industry is passing through this period of reorganization and extension. It is academic to say that the greatest obligation of public service companies is service. After all, a private enterprise is a private venture; but the service is imperative; service is the criterion. Based on his own observations, author believes that a community thoroughly aroused against a utility can pursue that company to its financial ruin. Prudence all along the line should govern the counsels of the management of a public service company. In his opinion mistakes in judgment have been made where these new managements have removed from their local employ citizens who were well known and locally respected. The supplanting of these local men by officials brought in from a distance creates in some instances suspicion and active resentment. Public confidence is an asset cheap at any reasonable cost.—*E. E. Bankson.*

Service Lines. W. C. HAWLEY. Pennsylvania Water Works Ass'n. 1928 Report, 145. In a normal water works plant no part of the system has such a direct and important effect upon the quality of the service rendered, as the service lines. Their cost constitutes a substantial part of the total investment in plant and their maintenance, an important item of annual expense. Then follows a discussion of construction details and merits of the various types of materials used in service line construction. Service lines should be laid at depths sufficient to protect them from frost.—*E. E. Bankson.*

Water Mergers and the Public Convenience JOHN H. MURDOCH, Jr. Pennsylvania Water Works Ass'n. 1928 Report, 158. Doubts very much if there is any way by which it could be shown that the State of Pennsylvania was opposed to water mergers and not in favor of municipal purchase. The

Commission very properly will scrutinize more carefully the accounts and records of companies controlled by a holding company than they will those of a small independent company. If the methods of financing and the methods of operation of holding companies are unsound economically, those methods will fail to produce satisfactory results and will be discarded in a comparatively short time and no amount of argument and no amount of excitement propaganda on either side will change the ultimate result.—*E. E. Bankson.*

Recent Federal Decisions. JOS. A. BECK. Pennsylvania Water Works Ass'n. 1928 Report, 175. Dealing with Federal decisions affecting public utilities during the last 12-month period.—*E. E. Bankson.*

Note on Clark Meter Testing Machine. H. W. Clark Company of Mattoon, Ill. announces a slight change in the Clark meter testing machine. The electric alarm bell used to signal the closing of the test on water meters has been replaced by a buzzer. In testing on a small flow or on quantity tests for accuracy, the operator may leave the machine and occupy himself with other duties. The buzzer calls the operator a few seconds before the close of the test.—*A. W. Blohm.*

Electric Fish Screen. F. O. MCMILLAN. Bulletin, U. S. Bureau of Fisheries, **44**: 1928. Document No. 1042. Because of the millions of fish that are killed annually in navigation canals or by passing through hydraulic turbines, etc., a study of the effect of the electric screen upon the fish was made. The problems studied were: what uniform voltage gradient in water will paralyze fish, and its variation with the length of fish; effect of voltage gradient upon mortality of fish; after effects of shock; resistivity of water upon voltage gradient required to produce paralysis; do fish sense direction of danger around electric screen and will an electric screen effectively prevent fish entering a protected area? Tests were carried on in both concrete tanks and also under natural stream conditions. The conclusions reached from this investigation were: a very simple relation exists between minimum voltage gradient required to paralyze fish and their length expressed by the equation $g = \frac{3.70W}{L}$ where g = voltage gradient in volts per inch, W = water-resistivity correction factor and L = length of fish in inches; when voltage gradients above paralysis values are applied to fish, mortality increases with increased time of application; fish subjected to electric shocks in various degrees, if not killed outright, quickly recover and suffer no serious after effects; resistivity of water has an important influence upon voltage gradient required to produce paralysis; very large variations are found in resistivity of water from various streams; fish do have a sense of danger in electrified area and try to avoid it; to be effective, an electric screen must have the lines of current perpendicular to the plane of protected opening and the equipotential surfaces parallel with this plane; lines of electric current flow must be parallel with direction of stream flow; experimental electric fish screens have been very successful. Actual stream installations should now be made, carefully observed and developed.—*A. W. Blohm.*

The "Cajo" Gas Leak Detector. Bulletin, No. 200. Colonial Supply Company, Pittsburgh, Pa. The Cajo gas leak detector is designed to indicate instantaneously the presence of small amounts of light as well as heavy gases mixed with air. The main part of the detector consists of a porous clay cylinder connected with a diaphragm by means of a small tube. Through the walls of the completely closed cylinder, filled with and surrounded by air, a constant interchange of gas from inside to outside, and vice versa, takes place at uniform rate. If the surrounding gas is lighter than air, the transfusion from outside to inside is faster than from inside to outside and results in a pressure increase in the cylinder. If the surrounding gas is heavier than air the reverse operation takes place and a decrease in pressure will be observed. The pressure differences act on the diaphragm, the raising or lowering of which opens or closes an electric contact. Its sensitivity permits the detection of an illuminating gas content in air as low as 0.03 per cent.—*A. W. Blohm.*

On the Control and the Degree of Reliability of the Chlorination-Process of Drinking Water, in Connection with the Chloramin-Procedure and the Chlorination of Ammoniacal Water. (First Part). K. Holwerda. Meded. Dienst. d. Volksgezondheid in Nederl.-Indie., 1928, 17: 251–97. From Bull. Hyg., 4: 4, 315–6, April, 1929. In general, little consideration has been given to the chemical condition of the active chlorine or to the effect of reducing substances present in the water in making studies of the sterilizing power of chlorine. Hence, the length of time a given concentration of chlorine is active is not known. "Active chlorine may exist as hypochlorite, hypochlorous acid, or free chlorine, as chloramines, or as substitution products of organic nitrogen compounds." Water almost free of organic matter and with the traces of ammonia removed was used in the experiments. It was found that the pH value had great influence on sterilization by means of hypochlorite. For example, at pH of 8, 18.7 per cent only of the active chlorine was present as HClO, but at pH of 6, practically 100 per cent. Chlorine added as gas in normal doses for water treatment is also present as HClO. Hence it is only necessary to consider the action of the hypochlorous acid molecule and the hypochlorite ion and the ratio HClO/OCl; is determined entirely by the pH value after establishment of equilibrium. At pH = 7 or less, the influence of changes of pH on the progress of sterilization was small; but for values greater than 7, such changes have great effect and indicate that the hypochlorous acid molecule has considerably greater sterilizing power than the hypochlorite ion. For safety, therefore, it is advisable to tabulate from the results of experiments, the contact period necessary to secure effective treatment for pH = 8, and then by giving the same contact period for a lesser pH, the margin of safety will be increased. Contrary to the belief of some, chloramine is not a more powerful disinfecting agent than chlorine. A table in the article shows that the disinfection period for 0.1 p.p.m. of active chlorine present as hypochlorite is 10 minutes, while for the same amount present as chloramine, the period extends to 6 hours. A number of methods of determining and estimating chlorine are discussed very briefly. One for estimating hypochlorite chlorine by means of 1 in 5000 methyl orange is quoted. "The methyl orange is run from a burette into 100 cc. of the water to be tested until

a drop gives a permanent red colour. The volume of methyl orange required is not strictly proportionate to the amount of hypochlorite and a table is provided from which the chlorine concentration corresponding to a given titre of methyl orange can be read off. Results are accurate to 0.03 p.p.m. of chlorine."—*Arthur P. Miller.*

Some Biochemical Relationships in a Polluted Stream. H. HEUKELEKIAN. Public Health Reports, **44**: 26, 1544–1555, June 28, 1929. In 1927 a one-year survey was made of the extent and intensity of pollution in the Raritan River, N. J., representing a drainage area of 1105 square miles. "The lower Raritan River receives the raw sewage from a total population of about 100,000, as well as the effluent from the Plainfield, N. Plainfield, and Dunellen disposal plant." Practically untreated industrial waste, a pollution estimated as being equivalent to 80,000 population, is also added. River flow for 1927 was 30 per cent higher than the preceding five-year average. From seven points samples were collected semi-monthly, except in September, when collections were made weekly. Analyses were made for pH, alkalinity, chlorides, ammonia, nitrites, nitrates, suspended solids, ash, dissolved oxygen, 5-day B. O. D., 20° agar counts, *B. coli*, and plankton. The author reports that the pollution reaches a maximum just below New Brunswick. The process of self-purification is evidenced by: "The reduction of numbers of *B. coli* and pollutional forms of plankton by a dam, the lowering of oxygen saturation (due to bacterial activities)" and the movement of zone of maximum pollution farther upstream in summer. Dilution with sea water is a major factor in river improvement below New Brunswick. Total bacteria and *B. coli* parallel each other closely; the numbers of both, also, being higher in summer than in winter. "Pollutional plankton forms increased at a point farther up stream than did *B. coli* or total bacteria." Direct relationship exists between the numbers of bacteria, B. O. D., and the ammonia nitrogen. Heavy pollution decreases the nitrates by depletion of oxygen. Several charts are included. Appended are references to the comprehensive studies of pollution and purification of the Ohio and Illinois Rivers made by the U. S. Public Health Service.—*R. E. Noble.*

Operating Aspects of Water Service. C. R. KNOWLES. Ry. Age, **86**: 26, 1569–1571, June 29, 1929. General review of railway water service activities given, including estimate of 200 billion gallons treated annually at a cost of \$10,000,000.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Progress Being Made by Federal and State Authorities on Regulations Pertaining to Drinking Water Supply. Com. Rep., S. C. BEACH. Chairman, Amer. Ry. Eng'ring Assoc. Proc., 30: 201, 1929. Manual of recommended practice on Railway Sanitation is being prepared.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Methods of Providing Drinking Water at Coach Yards, Including Study of Hydrants, Nozzles, Connections, etc. Com. Rep. C. M. BARDWELL, Chairman, Amer. Ry. Eng'ring Assoc. Proc., 30: 202–206, 1929. The sanitary hand-

ling of supplying drinking water to passenger coaches where through trains are watered is handicapped by lack of time. Better instruction of forces is recommended.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Uses of Copper-Bearing Steel for Structural Purposes. Com. Rep., F. P. Turner, Chairman, Amer. Ry. Eng'ring. Assoc. Proc., 30: 1015–1017, 1929. Information collected indicates increased use of Cu-bearing steel for steel cars, tie plates, track spikes, smoke stacks, boilers, culvert pipe, flashings, ventilators, fencing, structural steel, sash, power line supports, flood light towers, and overhead electrification structures for railway tracks.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Study and Report on Water Columns; Their Advantage over Tank Delivery, Required Range of Operation, Type of Pit, and Relative Merits of Rigid and Telescopic Spouts. Com. Rep., J. P. Hanley, Chairman, Amer. Ry. Eng'ring. Assoc. Proc., 30: 187–200, 1929. General description of various installations with charts showing expected deliveries at various heads.—*R. C. Bardwell.*

Study of Protective Coatings for Interior of Steel Tanks and Underground Pipe Lines. Com. Rep., J. H. Davidson, Chairman, Amer. Ry. Eng'ring. Assoc., 30: 143–153, 1929. Railways Engineering and Maintenance, 25: 6, 244–247, June, 1929. Coatings of Portland cement grout, or of preparation of a petroleum base into which rust inhibiting chemicals have been compounded, or of asphaltic liquid paints, appear to have given better results for protection on interior of steel water tanks than red lead and linseed oil customarily used. In underground pipe lines, records indicate Portland cement much the best, bituminous coatings wrapped, next, and paint coatings, as imparting the lowest increase in life.—*R. C. Bardwell (Courtesy Chem. Abst.).*

The Causes and Extent of Pitting and Corrosion of Locomotive Boiler Tubes and Sheets, Giving Consideration to Quality of Water, Character of Metals, Methods of Manufacture, and Types of Construction. Amer. Ry. Eng'ring. Assoc. Proc., 30: 126–132, 1929. Com. Rep., O. T. Rees, Chairman. With review of railroad conditions, following recommendations are made to reduce pitting and corrosion; use corrosion resistant material; eliminate defects in manufacture; equalize strains by proper design; remove gases from water by feed-water heaters; remove Mg salts from water; reduce H-ion concentration; carry excess NaOH in boiler waters; and protect boiler from corrosion during storage.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Building Water Stations "Out of Face." C. R. Knowles, Railway Engineering and Maintenance, 25: 5, 204–208, May, 1929. The Illinois Central R.R. has provided 8 new plants with total annual capacity of 336,000,000 gallons for new 169-mile line from Edgewood, Ill., to Fulton, Ky. Ground water supplies being limited and of poor quality, reservoirs were required to conserve surface supplies. Standardization was followed as far as possible with oil engine power units, centrifugal pumps, pipe lines, and 100,000-gallon creosoted pine storage tanks.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Locating Old Pipe Lines. W. B. McCaleb. Railway Engineering and Maintenance, 25: 5, 224–225, May, 1929. Methods using sound and methods with geophone, transmittophone, or leak detector, are described and recommended.—*R. C. Bardwell.*

Dearborn-Wagner Feedwater Purifier. Anon. Railway Age, 87: 2, 161, July 13, 1929. A secondary steam dome on first course of locomotive boiler contains series of trays over which feedwater falls with view to discharging scaling impurities before water is conducted to bottom of boiler between circular baffle and boiler shell. Small depression is made in bottom of boiler shell to hold impurities for removal by blow-off cock. Device is claimed to assist results with either internal or external water treatment, but no figures are given on installation or maintenance expense.—*R. C. Bardwell (Courtesy Chem. Abst.).*

New Haven Solves Interesting Power Plant Water Supply Problem. Anon. Railway Age, 85: 24, 1175–1179, December 15, 1928. Boiler water problem for the large power plant of the N. Y. N. H. and H. R.R. at Cos Cob, Conn., was solved by damming the Mianus River to prevent salt water tide pollution. Water is treated with alum before running through four pressure type filters. $CuSO_4$ is used for controlling algae growth in reservoir. Pumping equipment is 5-inch centrifugal driven by 55-h.p. oil engine. Details of dam construction, of engine and pump setting, and of pipe layout are given.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Coöperation Produces Results in Water Treatment. R. E. Coughlan. Railway Engineering and Maintenance, 25: 4, 158–161, April, 1929. Water supply used on the 10,215 miles of the Chicago and Northwestern R.R. varies in total dissolved solid content from 3.0 to 209.74 grains per gallon. First water softening plant was built in 1904 and 53 are now in service. At other points, boiler compound made by company forces is used through special device attached to the locomotives. Blow-off schedule is in effect and corrosion investigation is under way.—*R. C. Bardwell (Courtesy Chem Abst.).*

Chicago and Alton Checks Corrosion in Locomotive Boilers. Anon. Railway Age, 86: 15, 828–832, April 13, 1929. Since 1924 the C and A. R.R. has equipped 75 locomotives with electrodes for treating the water with a weak arsenic compound in order to prevent corrosion. Scaling matter in water supplies varies from 2.8 to 52.2 grains per gallon, with non-carbonate hardness between 0.6 and 28.9 grains per gallon. Scale troubles were overcome by removing non-carbonate hardness with soda ash at all wayside tanks, but pitting resulted which gave trouble until counteracted by the electro-arsenic treatment called the Gunderson Process which has given good results at low cost.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Report on the Design and Maintenance of Track Pans for Locomotive Supply. W. B. McCaleb. Amer. Ry. Eng'ring Assoc., 30: 173–181, 1929. Due to high cost of installation, operation, and maintenance, location of track pans

for supplying water to locomotives requires special study. The probable average efficiency of water in pan to that taken by locomotive is 65 per cent, when drainage and ice removal, together with heating, have been considered. Typical designs and operating costs are shown.—*R. C. Bardwell.*

Methods Used in Obtaining Successful Wells in Fine Sand Formation. Com. Rep., J. R. Hickox, Chairman, Amer. Ry. Eng'ring Assoc. Proc., 30: 182–186, 1929. Large casing with inserted gravel wall around well screen is recommended.—*R. C. Bardwell.*

Cost of Impurities in Locomotive Water; Report on Methods of Water Treatment Where Complete Lime and Soda-Ash Treating Plants Cannot be Justified, or Pending their Construction. Com. Rep., C. H. Koyl, Chairman, Amer. Ry. Eng'ring. Assoc. Proc., 30: 133–138, 1929. Soda-ash, sodium aluminate, and proprietary compounds are recommended.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Cost of Impurities in Locomotive Water; Review Progress in Water Treatment on Railroads and Report on Possible Future Development. Com. Rep., C. H. Koyl, Chairman, Amer. Ry. Eng'ring. Assoc. Proc., 30: 139–142, 1929.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Study and Report on Incrustation in Pipe Lines and Methods of Prevention, Particularly Where Treated Water is Used. Com. Rep., E. M. Grime, Chairman, Amer. Ry. Eng'ring Assoc. Proc., 30: 154–157, 1929. Softening of water to one grain per gallon or less, will reduce incrustation materially. CO_2 treatment is not desirable in boiler water supplies.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Report on the Use of Gravity and Pressure Filters. Com. Rep., D. A. Steel, Chairman, Amer. Ry. Eng'ring. Assoc. Proc., 30: 158–170, 1929. Survey indicates that only a small percentage of Railway water supplies are equipped with filters. Rapid gravity type is preferred. General description outlining fundamental principles is given.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Treating a Low Hardness Water Saves $48,000 per Annum. Anom. Railway Engineering and Maintenance, 25: 2, 46–49, February, 1929. The Chicago, Rock Island, and Pacific R.R. recently completed a complete new water station for its terminal at Silvis, Ill., to pump and treat Mississippi River water at rate of 100,000 gallons per hour. Electrically operated centrifugal pumps are used with moving intake screen. Lime, soda-ash and sodium aluminate are used for treating the water in 50-foot diameter by 62 feet high steel tank with 12-foot diameter downtake equipped with 20 agitator paddles. Incrusting matter is reduced from 14 to 1.5 grains per gallon, effecting net annual saving of $48,000.—*R. C. Bardwell (Courtesy Chem. Abst.).*

NEW BOOKS

Bioprecipitation Studies, 1921–1927. Illinois State Water Survey Div., Bul. 25: A. M. Buswell, R. A. Shive, and S. L. Neave. 94 pages. 1928. Contents deal with sewage treatment studies. Bioprecipitation may be defined as precipitation of colloids upon ingestion by microörganisms of such growth habits that they form large compact flocs which will settle out.—*R. E. Noble.*

The Depth of Sewage Filters and the Degree of Purification. Illinois State Water Survey Div., Bul. 26: A. M Buswell, S. I. Strickhouser, and others. 100 pages. 1928.—*R. E. Noble.*

A Study of Factors Affecting the Efficiency and Design of Farm Septic Tanks. Illinois State Water Survey, Div., Bul. 27: E. W. Lehmann, R. C. Kelleher and A. M. Buswell. 45 pages. 1928.—*R. E. Noble.*

Pacific States. Surface Water Supply of the United States, 1924. Part XII.—North Pacific Slope Drainage Basins. B—Snake River Basin. N. C. Grover, G. C. Baldwin, G. I. Parker, C. G. Paulsen, A. B. Purton, and F. F. Henshaw. Water-supply Paper 593.—*Arthur P. Miller.*

Grundwasserkunde. W. Koehne. Stuttgart. Schweizerbartsche Verlagsbuchhandlung, 291 pp. 1928. A comprehensive but concise textbook in 12 chapters, on ground water, by which the author means the water in the zone of saturation, as distinguished from subsurface water which includes also the water in the zone of aëration. Chapter 1 defines the fundamental concepts of the subject, including the two zones above mentioned, the three belts of the upper zone—capillary fringe, belt of soil water (Boden), and intermediate belt; specific yield and specific retention; absolute and hydraulic permeability; suspended water (Haftwasster); perched ground water (schwebendes Grundwasser); and phreatophytes. Chapters 2–4 deal with absorption of surface water, fluctuations of the water table, with variations in recharge and discharge, relation of rock structure to the circulation of subsurface water and occurrence of artesian water, and the velocity of ground water. Chapter 5 discusses formulae applicable to ground-water hydrology and states that Darcy's law is substantially valid though there are slight variations from it in coarse materials; concludes that mathematical formulae for yield of wells are inadequate for determining supplies available for large developments. Chapter 6 discusses effects on ground water levels produced by wells, mines, canals, and drainage systems. Chapter 7 discusses methods of sinking test holes, measuring depths to the water table, taking samples of the water-bearing materials, and laboratory methods of examining the materials, especially for specific yield (Spezifische Wasserlieferung) and permeability; also computation of velocity of ground water from permeability and field determination of velocity by means of dyes or salts. Chapter 8 discusses methods of investigating the movements of ground water; contour maps of the water table; relations between stage of the water table and precipitation; ground-water run-off; etc.

Chapter 9 discusses the relation of plants to ground water in arid and humid regions. Relations in arid regions are discussed very briefly without reference to the work done in the United States, but there is more detailed summary of European work on relations in bottom lands and of field crops, vegetables, fruit trees, and forest trees. Chapter 10 describes the ground-water supplies for Berlin and other German cities; also governmental organizations for investigating ground water, including the ground-water division of the U. S. Geological Survey. Chapter 11 discusses ground water and "Haftwasser" in relation to foundations and mining operations, and Chapter 12 summarizes the relation of subsurface water to human affairs, subdividing its effects into essential, useful, and harmful. A bibliography and a glossary are appended.—*(From abstract by O. E. Meinzer) David G. Thompson.*

Untersuchung und Wertbestimmung von Mineralwassern und Mineralquellen (Investigation and Appraisal of Mineral Waters and Mineral Springs). H. Kionka. Handb. d. biol. Arbeithsmeth., Abt. IV, T. 8, H. 8, pp. 1927–2146, Urban u. Schwarzenberg, Berlin, 1928. A discussion of the topographic environments of mineral springs, the geology of such springs with respect to the source of the water, origin of the springs, source of dissolved constituents, formation of spring deposits, circulation of ground water, and hydraulics and physical and chemical relations of springs. (Summarized from abstract No. 1282, by K. Keilhack: Geol. Zentralblatt, 37: 8, Aug. 1, 1928).—*(From abstract by Arthur M. Piper) David G. Thompson.*